

The epidemiology of head injuries in an urban/rural population,
together with an evaluation of a more selective admission policy.

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Doctor of Medicine

University of Edinburgh

1984



CONTENTS

ACKNOWLEDGMENTS	1
PREFACE	3
CHAPTER I - INTRODUCTION	1
CHAPTER II - HISTORY OF THE LITERATURE	1
1.1. Introduction	1
1.2. Background	12
1.3. Cultural Background	13
1.4. Historical Background	14
THIS WORK IS DEDICATED TO THE MEMORY OF MY LATE FATHER, FRANCIS JOSEPH GORMAN, WITHOUT WHOM MANY THINGS WOULD HAVE BEEN IMPOSSIBLE.	
CHAPTER III - BIBLIOGRAPHIC STUDY 1914 - 1920	15
CHAPTER IV - Bibliographic Study 1921 - 1930	16
CHAPTER V - Bibliography	17
1.1. Introduction	17
1.2. Bibliography	18
1.3. Bibliography	19
1.4. Bibliography and Bibliography	20
1.5. Bibliography of Bibliography	21

C O N T E N T S

	Declaration	
	Abstract	
CHAPTER 1	Introduction	1
CHAPTER 2	Review Of The Literature	
	2.1 Epidemiology	5
	2.2 Pathology	151
	2.3 Extradural Haematoma	193
	2.4 Subdural Haematoma	239
	2.5 Skull X-ray	297
	2.6 Admission Policy	333
CHAPTER 3	Retrospective Study 1976 - 1977	355
CHAPTER 4	Prospective Study 1979 - 1980	448
CHAPTER 5	Discussion	563
	Acknowledgements	591
	References	593
	Appendix	
	Further background and methodology	634
	Summary of conclusions	638

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DECLARATION

I, David Francis Gorman, hereby own and declare that this thesis was composed by myself alone.

Signed by: .
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ABSTRACT OF THESIS (Regulation 6.9)

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Title of Thesis THE EPIDEMIOLOGY OF HEAD INJURIES IN AN URBAN/RURAL POPULATION,
..... TOGETHER WITH AN EVALUATION OF A MORE SELECTIVE ADMISSION POLICY.....

The epidemiological characteristics of two groups of patients with head injuries attending the accident and emergency department at Chester Royal Infirmary are detailed. This hospital serves a mixed urban/rural population of approximately 260,000. The earlier study comprised all those who attended during the twelve months ending 30.6.77 and was retrospective. The later study included all attenders in the year ending 30.11.80 and was prospective. During each study period patient characteristics, including age last birthday, sex, time, day and month of attendance were recorded, in addition to cause of injury and predisposing factors or associations such as alcohol. Some elements of the history and examination were also noted. X-ray usage was documented as well as the proportion of patients with radiologically apparent skull fractures. Some treatment measures were quantified. For admitted patients, in addition to the above characteristics, reasons for admission and length of stay were examined. Macroscopic post-mortem findings were described for all patients who died, including those who died prior to arrival at hospital. Analysis of deaths included the calculation of Injury Severity Scores. Results were discussed in the light of an extensive review of the literature.

A more selective admission policy was introduced during the prospective study. As a result of this change head injury admissions were reduced by half. Comparison of the results during the prospective study with those during the retrospective study, when a more orthodox admission policy was in use, revealed that the more selective policy was associated with no worse results than is current practice. Recognition and treatment of acute post-traumatic intracranial haematomas, whilst the patient was alive, was more likely during the prospective study. Likewise survival of patients with such lesions was more likely during the prospective study. These latter differences between the two study groups were, however, not statistically significant.

CHAPTER 1

Introduction

Accidents, their prevention and the treatment of their victims present one of the remaining challenges of modern medicine. They constitute a worldwide problem from which no country is immune. In 1963 accidents, poisonings and violence were the second commonest cause of lost years of life in Australian males and fifth commonest in Australian females (1). The importance of this group of causes is further emphasised when years of lost working life are computed, since the major cause of lost years of life, cardiovascular diseases, affects mainly older people, whereas accidents, poisonings and violence affect mainly the young. Thus accidents, poisonings and violence were the commonest cause of lost years of working life in Australian men and third commonest in Australian women in 1963 (1). Motor accidents accounted for 10% of lost years of life in Australian males in 1969 and 5% of lost years of life in Australian females in the same year (2). These proportions represent a 31% increase in males and a 64% increase in females in the proportion of lost years of life due to motor accidents in 1963 (2). A large part of these lost years due to accidents, and particularly traffic accidents, occur directly as a result of head injury. In England and Wales in 1979, accidents (International Classification of Diseases, rubrics E800-E949) were the third commonest cause of lost years of life in males aged 15-64 years and sixth commonest in females (3). Road traffic accidents accounted for 63% of these lost years in men and 53% in women. For all ages up to eighty-five years, accidents were the fourth commonest cause of years of total life lost in both males and females. Accidents accounted for 2.8% of male deaths from all causes and 2.2% of all female deaths but 16% of lost years of working life in males and 7.7% of lost years of working life in females (3). When deaths due to suicide are added to the total

number of accidental deaths for 1979 then this group of causes ranks second in males and third in females among causes of lost years of working life (3).

In the United States from 1967 to 1975 accidents were the fourth commonest cause of death overall and the commonest cause in ages 1-44 years (4, 5), although more recently this age range has narrowed to 1-33 years (6). About half of these deaths were due to road traffic accidents and head injury was involved in 70% of traffic deaths (4). During 1976 one hundred thousand Americans died as a result of accidents (6). In the same year more than a quarter of the US population suffered an accident, 7.56 million of these were head injuries, that is 3.6% of the total population and more than half were less than seventeen years old (6). These head injuries, of which 83% were 'minor' and 17% 'major', produced 24.5 million days of restricted activity and 10.2 million days of bed disability. The estimated cost in lost wages and medical expenses was 2,240 million dollars. National statistics for England and Wales agree with those from the United States. Thus for the years 1977 to 1981 inclusive, accidents were the commonest cause of death in those aged 1-34 years and third commonest in those aged 35-44 years (7, 8, 9, 10, 11). Furthermore, in 1980, 51% of accidental deaths (ICD E800-E949) in males and 30% of accidental deaths in females were the result of road traffic accidents (12). During 1980 accidental deaths in England and Wales numbered 14,042 (8040 males and 6002 females). For the same year head injury deaths (ICD N800-N804, N850-N854) totalled 4,385 of which 3,974 were the result of accidents i.e., 28% of all accidental deaths (33% of male and 21% of female accidental deaths) (12).

Between 1955 and 1963 hospital admissions for head injury in England and Wales increased by over 50% (13) and between 1963 and 1972 by more than 40% (14). Most of the latter increase was due to the admission of more minor head injuries (those discharged in twenty-four hours or less), while admissions for more than twenty-four hours remained almost unchanged (14). Craft (15) stated that more than 20% of all children older than one year admitted to

hospital in England and Wales each year are admitted because of accidents. He also pointed out that in Newcastle between 1950 and 1972 there was a sixfold increase in the number of children admitted to hospital with head injuries. In one Glasgow hospital in the year ending August, 1974 27% of adult, acute male surgical admissions were because of head injury (16). The Scottish Head Injury Management Study suggested 10% of all new attendances at accident and emergency departments were by patients who had sustained a head injury (17) and that 23% of these were admitted (18). During the same year the annual admission rate in England and Wales was 14% lower than that in Scotland (19). The discharge rate for head injuries in 1968 in Scotland was 294/100,000, by 1979 this had risen to 418/100,000 (20).

If these trends have continued, then in 1983, approximately one million patients with head injury might be expected to attend accident and emergency departments in Britain and up to two hundred thousand of these are likely to be admitted, most for twenty-four hours or less. Perhaps five thousand will die and most of these will be young and male. In general terms, two thousand will die after admission, one thousand will die in accident and emergency departments and two thousand elsewhere, largely prior to arrival at hospital (14, 21). If London's (22) estimate of 1% of admissions still holds, then two thousand new 'lame brains' will be created and half of these will never work again. Similarly, Jennett's (23, 24) estimate for the incidence of epilepsy following head injury would indicate that ten thousand patients will develop 'early epilepsy' in 1983, a similar number 'late epilepsy' and more than sixteen thousand will experience epilepsy at some time after their injury. Skull fracture on X-ray will occur in approximately 7% of all patients admitted (25) and a smaller proportion will develop a post-traumatic intracranial haematoma - 0.8% of adults according to the report of Galbraith et al (16). However, Jennett and MacMillan (19) have remarked on the decline in the incidence of severe head injury and of head injury deaths. Because of the increasing number of minor injuries admitted and the relatively constant or declining number of more serious injuries, some of the estimates in this

paragraph are probably too high and this is likely to apply particularly to the estimates for epilepsy and for lame brains.

One could be forgiven for thinking from the foregoing that the epidemiology of such a common and serious problem must have been well researched. However as recently as 1976, Field (14) was able to point to deficiencies in this very aspect of head injury, particularly in regard to accident and emergency departments. Furthermore in 1978 Kraus (26) described the epidemiology of head injury as being woefully incomplete. Since that time Kraus and Jennett have been involved in research designed to remedy these deficiencies, Kraus through his work with the National Head and Spinal Cord Injury Survey (27, 28) and Jennett through his involvement with the Scottish Head Injury Management Study (17, 18, 25, 29).

The study described here was begun in 1977 in response to the observations of Field, and seeks to provide additional epidemiological data, particularly concerning accident and emergency patients. At the same time the opportunity was taken to introduce an alternative admission policy on a prospective basis.

CHAPTER 2

Review Of The Literature

2.1 EPIDEMIOLOGY:

Articles concerned exclusively with the epidemiology of head injuries are few. Most often information regarding this topic has to be abstracted from works essentially addressing other aspects of head injury, when brief epidemiological data is incidental to the main body of the work. The majority of articles deal only with admitted patients or concentrate on complications, specific age-groups, typically children, specific causes, most often road accidents, or particular associations such as alcohol. Many fail to include demographic details of the general population from which the head-injured group was drawn. Nevertheless useful epidemiological information can be gleaned from these diverse sources provided some critical questions are posed in regard to each work. Answering such questions may then allow reasonable deductions and comparisons to be made between different works.

Few authors include a definition of what they consider to constitute head injury. Two of those that do include such a definition, Anderson, Kalsbeek and Hartwell (30) and the Scottish Head Injury Management Study (SHIMS) (17), are quite clearly identifying different sub-groups of head-injured patients. Thus for the National Head and Spinal Cord Injury Survey, head injury was defined simply as trauma to the brain, however patients must also have been admitted for in-patient care (30). This narrow definition excluded patients seen in, and then discharged from emergency rooms, as well as patients dying prior to admission. SHIMS used a broader definition allowing the inclusion of all patients attending Accident and Emergency Departments (AED) as well as all admitted patients. Apparently this latter study also excluded patients dying at the scene or en route to hospital, although this is not clear from the

text. In the absence of a clearly stated definition, therefore, it cannot be assumed when comparing series that a universally agreed but unstated definition of head injury is being used. Any publication not defining head injury must be faulted at the outset in this regard. Similarly, comparing series relating to admitted patients, where an implicit definition at least in part exists, may be impossible on a like with like basis without knowing the admission criteria in operation.

Teasdale, Parker et al (31) have stated that for serious head injury (defined as patients in coma for at least six hours) valid comparisons between different series can only be made when the distribution of characteristics within each series is similar. They illustrated this by constructing three series of patients each with the same mean age but differing age distributions and showing the expected mortality to vary between 38% and 52%. They also illustrated how sample size could affect the observed frequency of results, thus a sample of twenty, with an observed frequency for a particular characteristic in the range 5%-35% would not differ significantly from a much larger sample of a thousand with an observed frequency for the same characteristic in the range 17%-23%. The accuracy of a sample increases with the square root of the sample size so that a sample must be increased one hundredfold to obtain a tenfold increase in accuracy.

Again discussing head-injured patients in coma for at least six hours, Teasdale, Skene et al (32) were able to show that age is an indicator of outcome even when many other factors have been considered. Previously, Kerr et al (33), when describing a group of generally less severely injured patients used discriminant function analysis to show that for patients over fifty years old, age alone predicted death. Baker et al (34), Baker and O'Neill (35) and Bull (36, 37) have also demonstrated the relationship between age and mortality for all degrees of severity and type of injury following road traffic accidents (RTA), many of which must have included head injury. The influence of age on mortality and ultimate disability following head injury has also been reported by many other workers

(38, 39, 40, 41, 42). Other factors which affect outcome include: conscious level (33, 38, 39, 40, 41, 42), type of accident, e.g. there is a higher mortality associated with RTA (33, 42, 43), duration of post-traumatic amnesia (33, 40, 41, 44, 45) and associated injuries (33, 34, 35, 36, 37). Inclusion of secondary referrals will also affect results, tending to increase morbidity and mortality since they will generally have more severe injuries. In the same way types of accident more likely to cause serious injury will be over-represented in such series.

The reliability of information provided by any sample depends on its size and its randomness. In medical research a presenting sample, i.e. a consecutive series of patients who present themselves for treatment of a particular complaint, is usually studied. Such a sample can often be accepted as being truly random. However, this is not always the case as exclusion of any cases from the series destroys the randomness and therefore prohibits drawing general conclusions. Patients lost to follow-up or with incomplete information are often excluded, whilst patients dying before admission are commonly excluded from hospital case-fatality rates. These exclusions may not be stated by the authors, only being apparent from a consideration of the results presented, when they may be the only explanation of distortions. Selection, often unwittingly, can also operate, especially in hospital work where patients are admitted because of the initial severity of their complaint or the development of complications. Results based on the use of questionnaires are fraught with their own set of difficulties including non-response, interviewer variability and the use of leading questions.

Broadly similar characteristics as regards age, sex, causes, mortality, post-traumatic epilepsy, post-traumatic intracranial haematoma and so on are likely to indicate broadly similar series. Conversely, widely dissimilar rates for such characteristics imply some form of selection unless adequately explained by the authors. Urban/rural or other geographical differences may explain apparent discrepancies in some cases.

Generally in Britain the epidemiology of head injury is likely to be similar enough to enable a consensus based on published work to be arrived at. I now propose to attempt to establish such a consensus from a consideration of British studies, bearing in mind the critical questions which need to be asked in appraising such studies. Thereafter I will go on to consider other studies from around the world.

2.1.1 INCIDENCE:

No studies attempt to identify all cases of head injury, instead they confine themselves to larger or smaller sub-groups of the unknown absolute number. Usually this means patients who attend hospital and particularly those patients who are admitted.

a) General Practice:

The Second National Study of General Practice in England and Wales 1970-71 (46) reported an incidence of 190/100,000 for males and 90/100,000 for females, equivalent to approximately 140/100,000 overall. The sample size was small, only three hundred and eighty-seven cases, although the sample practices were selected to be representative of the whole country. If this study was representative then approximately 45,000 males and 23,000 females with head injury consulted their General Practitioners annually. For this study head injury was defined by the International Classification of Diseases (8th revision) rubrics N800-803 and N850-854.

The proportion of these patients who subsequently attend AED or who are admitted is unknown. Some indication of the degree of overlap with hospital patients can be gained from a brief report by Perkin (47). He studied three hundred and ninety-three head injury episodes in three hundred and forty-six patients in Redcar for the sixteen years up to 1975. Redcar is a small seaside resort in the North East of England and is therefore unlikely to be representative of the whole country. No definition of head injury

was stated. The average list size during the period studied was 6,300, which would indicate an incidence of 390/100,000. 34% of the total number of patients were referred to hospital and of these approximately two-thirds were admitted, the remaining third were discharged presumably after being seen in the AED. Of the total incidence 258/100,000 were dealt with entirely by their General Practitioners, 132/100,000 were referred to hospital and 91/100,000 from this latter group were admitted. Assuming all those referred to hospital were seen initially by the accident and emergency service, they would account for approximately 132/1620 or 8.1% of A&E attenders with head injury (1620/100,000 was the number of patients with head injury attending AED in Cleveland in 1974 (19).

b) Accident and Emergency Departments:

In 1976 Field (14) was unable to identify a single British paper dealing with this aspect of the epidemiology of head injury. Furthermore he was only able to discover two relevant overseas studies (48, 49). He went on to state that this lack constituted a major deficiency in available data. Since that time the situation has been somewhat improved as a result of work carried out in Scotland (17, 18, 50). These authors each used the same definition of head injury. Patients were selected by retrospectively sampling A&E departments during two randomly selected weeks in 1974, one week during the winter and one week during the summer. For the SHIMS (17), accident and emergency departments in the Lothians were excluded and 3035 patients were identified as having sustained head injury. Strang et al (18) and Jennett and MacMillan (19) both refer to a total of 3558 patients from all Scottish AEDs (forty hospitals). Presumably therefore the additional five hundred and twenty-three patients attended A&E departments in the Lothians. SHIMS suggested about 10% of all A&E attenders had a recent head injury, whilst Strang et al and Jennett and MacMillan reported 11% (range 6%-16%) with a lower proportion at city teaching hospitals (8%-9%). The overall attendance rate for A&E departments was 1778/100,000 (19) or 84,000 patients per year for the whole of Scotland (17). The incidence in the Cleveland area for the same

year was 1620/100,000 (19).

Using essentially the same definition as SHIMS, Swann et al (50) in a prospective study, recorded seven hundred and eighty-four adults (more than twelve years old) with recent head injury who attended the AED at Glasgow Royal Infirmary during an eleven week period in 1978. No details of catchment population for this inner city AED were given so that incidence figures cannot be determined for the age group under consideration. However, this group accounted for only 5% of new A&E patients during the study period. Weston (51) also confined his report to adults (aged fifteen years and over), extrapolating his yearly totals for 1977, 1978 and 1979 from a 10% sample of A&E attendances. Head injury was in part defined as was admission policy. During the years in question head injuries accounted for 10%, 8.7%, and 8.4% of new attendances respectively. Omission of demographical detail marred the recent paper describing A&E attendances with head injury in Newcastle (52).

c) Admissions:

This area contributes the bulk of the epidemiological information relating to head-injured patients. Lewin (43) reported that in England and Wales in 1950 there were 25,000 admissions for head injury following road traffic accidents (RTA's) and a further 10,000 admissions following head injury due to other causes. However, he accepted that this total of 35,000 head injury admissions was an underestimate, especially in the light of a cited admission rate of 120/100,000 based on work carried out in Glasgow. The same author (13) reported a 50% increase in head injury admissions in England and Wales from 1955-1963, while Field (14) reported an increase of more than 40% between 1963 and 1972. Thus in 1972 there were 142,000 head injury admissions in England and Wales and most of the increase over preceding years was due to an increase in the admission of more minor head injuries (14).

Rowbotham et al (42) described two thousand head-injured patients admitted to the Department of Neurological Surgery in

Newcastle between 1941 and 1951, with detailed analysis of the latter fourteen hundred admitted between 1945 and 1951. No definition of head injury was given, nor was admission policy stated. It also seems likely that a proportion of these patients were secondary referrals, although this was not stated.

Steadman and Graham (45) discussed four hundred and eighty-four patients admitted to Cardiff Royal Infirmary during 1958. 7.2% of these were secondary referrals and only 81% of the total were classified by age. The study was retrospective. Again no indication of admission policy was given although they did indicate how they selected head-injured patients. Despite defining the catchment population they did not determine how many patients with head injury were admitted to the only other hospital which served the same population, so that the incidence rates cannot be accurately determined. For example, if the split was 50:50 then the admission rate would have been 355/100,000, if the split was 25:75, with the larger proportion attending their hospital, the rate would have been 236/100,000 and if the same split occurred in the opposite direction the admission rate would have been 709/100,000. These authors also suggested that some patients with head injury might have been missed because other injuries formed the dominant problem and such patients might not have been identified by the diagnostic index as also having sustained head injury.

For the five years upto the end of 1961 the admission rate for head injury in an urban/rural area of Ayrshire was 59/100,000 (53). Although they included all head injury admissions, the authors did not define head injury and their only stated criterion used to select patients for admission was a history of unconsciousness. From the same unit as Rowbotham's earlier paper, Kerr et al (33) reported on four hundred and seventy-four patients admitted in the year up to the end of March, 1964. All patients were fifteen years old or over, 20% were secondary referrals, head injury was not defined and the only stated admission criterion was a period of unconsciousness following a head injury. The admission rate was 45.9/100,000 for males aged fifteen years and over and

9.7/100,000 for females. These figures, although similar to those from Kilmarnock must, for the reasons given above, be overestimates for the age group under consideration.

More recently Buxton (54) and Totten and Buxton (55) reviewed all head injuries (6103 patients) and all uncomplicated head injuries (5153) respectively, admitted to the Birmingham Accident Unit in the six years 1970-75. Population details were not given so admission rates cannot be determined. The ages of the patients were not specified. Minor head injuries were defined, but other types of head injury and admission policy were not.

A prospective study of the head injury admissions to a Glasgow teaching Hospital during the twelve month period ending in August, 1974, defined head injury as all patients included in ICD rubrics N800, 801, 803, 850-854 (16), [Field also included N802 - fractured facial bones and N804 - multiple fractures involving the skull and face with other bones, while SHIMS included N804 but not N802.] Any period of post-traumatic amnesia in a newly head-injured patient was considered to warrant admission. The study was confined to adults over the age of twelve years old and 27% of all acute adult male surgical admissions for the year under consideration were because of head injury. Although the catchment population was given, the authors did not specify what proportion of this population was under twelve years old. If all the stated catchment population were twelve years or over the admission rate for this age range would be 346/100,000.

The SHIMS (17) reported a retrospective survey of head injury admissions for two randomly selected fortnightly periods in 1974, one in winter and one in summer. All Scottish hospitals, except those in the Lothians, were included and eleven hundred and eighty-one head injury admissions were identified. From this sample they estimated that 15,000 patients with head injury were admitted to all Scottish hospitals in 1974 compared with the 15,229 hospital discharges recorded in the Scottish Hospital In-patient Statistics for the same year, an error of less than 2%. This study clearly

defined head injury, which approximated to the ICD rubrics utilised by Galbraith et al (16), although Galbraith did not apparently include N804 (multiple fractures involving skull or face with other bones). No indication of admission criteria was given. Jennett and MacMillan (19), analysing the above eleven hundred and eighty-one patients and the hospital admissions for head injury abstracted from the SHIPS for 1974, suggested an admission rate for head injury in Scotland in 1974 equal to 313/100,000 with a range 306-404. They also gave an admission rate for England and Wales of 270/100,00 with a range 210-360 based on the Hospital In-patient Enquiry for England and Wales (1974) and the Field report.

During 1975 and 1976 within the catchment area of the Mersey Regional Neurosurgical Unit, 20,273 patients with head injury were admitted to hospital, a rate of 312/100,000 (56). No definition of head injury or admission policy was given. This figure however is reasonably close to that suggested above for England and Wales by Jennett and MacMillan (19), especially as it relates to a slightly later period of time.

In Nottingham two thousand patients with head injury were admitted in 1976 and 1977 from a catchment population of approximately 750,000 (57). This represents an incidence of 133/100,000 and is clearly aberrant in view of the foregoing discussion. This has arisen because the age characteristics of the head injury admissions and the catchment population are not given. In fact the hospital from which the report originated does not admit children, while the figure given for the catchment population presumably included all ages, thus explaining why the apparent incidence is less than half that expected, based on other workers results. Additionally, no indication of admission policy or definition of head injury was given in this report. A later paper by Weston (51) indicated that all patients who had been unconscious, however briefly, were admitted during the above period.

Several British studies have concerned themselves exclusively with children - Boulis et al (58), Briscoe (59),

Burkinshaw (60), Craft et al (61), Jamison and Kaye (62), Partington (63) and Moyes (64). Three of these deal with highly selected populations, Boullis et al (58) consider only children under twelve years old who had a skull X-ray, while Briscoe (59) deals only with twelve to eighteen year old Eton schoolboys. The patients described by Moyes (64) were selected by virtue of the severity of their injury, their duration of stay and their age, and will be considered later. Burkinshaw's (60) clearly defined retrospective study of children up to thirteen years old admitted to a London hospital during the six year period 1951-56 did not allow incidence rates to be determined. Partington's study (63) can be criticised on the same grounds. Two studies from Newcastle do, however, allow incidence to be determined. Jamison and Kaye (62) reported a retrospective study covering the two year period up to October, 1969. All children admitted during this time who had received a blow to the head and had external evidence of injury, or who had a history of impaired consciousness, were included. However, children with a simple scalp laceration without loss of consciousness or other neurological symptoms or signs were excluded. A child with a closed skull fracture but without a history of impaired consciousness, external evidence of injury, neurological signs or symptoms would have been excluded therefore, a fact which seems unlikely. (This definition of head injury is a little woolly.) In addition twelve cases of non-accidental injury were excluded, whereas 18% of those included were secondary referrals admitted within twenty-four hours of their accident. During the study period 5385 children were admitted to hospital, 1179 because of trauma and 857 as a result of head injury. The upper age limit was not given but would appear to have been approximately fifteen years. The age specific admission rate for head injury in children as determined from this study was 42/100,000 excluding secondary referrals and 53.6/100,000 if all cases were included.

A prospective study also from Newcastle, identified two hundred cases of head injury admitted during a three and a half month period in 1971-72 (61). Since this period was in winter when childhood head injury is less common (62) the figures would yield an

underestimate if simply extrapolated for the whole year. Head injury was clearly defined and all children fulfilling the definition were included. The age range was nine days to fourteen years and seven months. 5% of patients were secondary referrals. Based on this study the estimated age specific annual admission rate was 543/100,000. This apparent tenfold increase in such a short time since Jamison and Kaye's study is accounted for by a marked difference in catchment population, 800,000 in Jamison and Kaye's paper (62) and 120,000 in that of Craft et al (61).

d) Neurosurgical Units:

Clearly, patients admitted to neurosurgical units (NSU) in Britain form a highly selected group. The report by Fahy et al (65) does not allow incidence figures to be calculated, nor does Moyes paper (64) dealing with children. In the studies already discussed there is considerable variation. 3% of hospital admissions for head injury in Scotland, excluding the Lothians, in 1974 were transferred to NSU's (17). For the two succeeding years in the Mersey Region, 1.2% of head injury admissions in the region were transferred to the regional NSU, a rate of 3.8/100,000 (56), while during 1976 and 1977 only 0.4% of adult head injuries in Nottingham were transferred to the NSU (57). The approximate admission rate in Scotland (excluding the Lothians) in 1974 was 11/100,000 (29), nearly three times that in the Mersey Region for the two succeeding years. Jennett and MacMillan (19) suggested that 3%-5% of admissions for head injury in Scotland (excluding the Lothians) were transferred to NSU and for England and Wales 5%, equivalent to a rate of 12-14/100,000 for England and Wales and most of Scotland, while the rate in Edinburgh may be 120-140/100,000.

In summary the following approximate incidence rates/100,000 for head injury applied in the early to middle 1970's. The figure of 274/100,000 for admissions is derived from the rates for England and Wales and for Scotland (19) assuming the population of Scotland is approximately one tenth that of England and Wales; while the figure for General Practice is a combination of

GENERAL PRACTICE: 140 - 93 treated entirely by G.P (i.e
two-thirds)
- 47 referred to A&E (i.e
one-third)

A&E DEPARTMENTS: 1778 - 47 from G.P (2.6%)
- 274 admitted (including 31 (11%)
from G.P)
(12-14 transferred
to NSU).

the National Study of General Practice (46) and Perkin's report (47), the overall figure of 1871/100,000 represents the best current estimate in the absence of community studies. More accurate figures would depend on a well devised and carried out study attempting to identify all patients attending General Practitioners, school nurses or doctors, industrial medical services, accident and emergency departments and hospitals, as well as those patients who sustain (minor) head injury but never seek medical advice. This would be a massive exercise, but well justified by the apparent size and importance of the problem, since accurate information would allow sensible disposition of resources and logistic arrangements, as well as being valuable in the field of prevention.

National statistics for England and Wales provide a larger view of the trends in the last twenty or so years. Results from the Hospital In-patient Enquiry covering the period 1960 - 1978 (14, 66, 67, 68, 69, 70) are shown in Table 2.1 and Figure 2.1. Most of the increase in the estimated total number of discharges and deaths during this period was due to an increase in the admission of patients with other and unspecified intracranial injury (N854). Patients in this category accounted for one third of all cases in 1960 (66) but two-thirds in 1978 (70). During the same period the total number of patients with this diagnosis more than trebled, whereas the number of discharges and deaths involving fractures of the facial bones (N802) increased by half and of patients with concussion (N850) decreased by one third. At the same time the

YEAR	TYPE OF HEAD INJURY				TOTAL
	MAJOR				
	N800-1	N802	N850	N854	
	N803-4 N851-3				
1960	13540	10150	33070	27980	84740
1961	14220	10420	35200	32950	92790
1962	13040	11230	35900	33530	93700
1963	13400	11270	36860	38970	100500
1964	14430	12150	38030	44450	109060
1965	15220	12380	39580	48180	115360
1966	14830	12480	38290	50700	116300
1967	14010	13460	33390	55100	115960
1968	13860	12420	31067	60824	118171
1969	12478	13470	31775	73338	131061
1970	12195	14263	30794	76613	133865
1971	13380	14870	29090	82540	139880
1972	11840	14380	27710	88130	142060
1973	11520	15230	25430	85810	137990
1974	10490	15180	26050	83470	135190
1975	10450	15440	26520	93820	146230
1976	10130	16320	26810	100310	153570
1977	9690	15700	23490	93560	142440
1978	9960	15210	22380	96470	144020

Table 2.1 Estimated total discharges and deaths from head injury by ICD codes England and Wales 1960 - 1978.

total number of discharges and deaths of patients with more serious head injury (N800, 801, 803, 804, 851, 852 and 853) also decreased by one third. This latter decrease concealed an increase of 34% in fractures of the vault of the skull (N800) whilst basal fractures

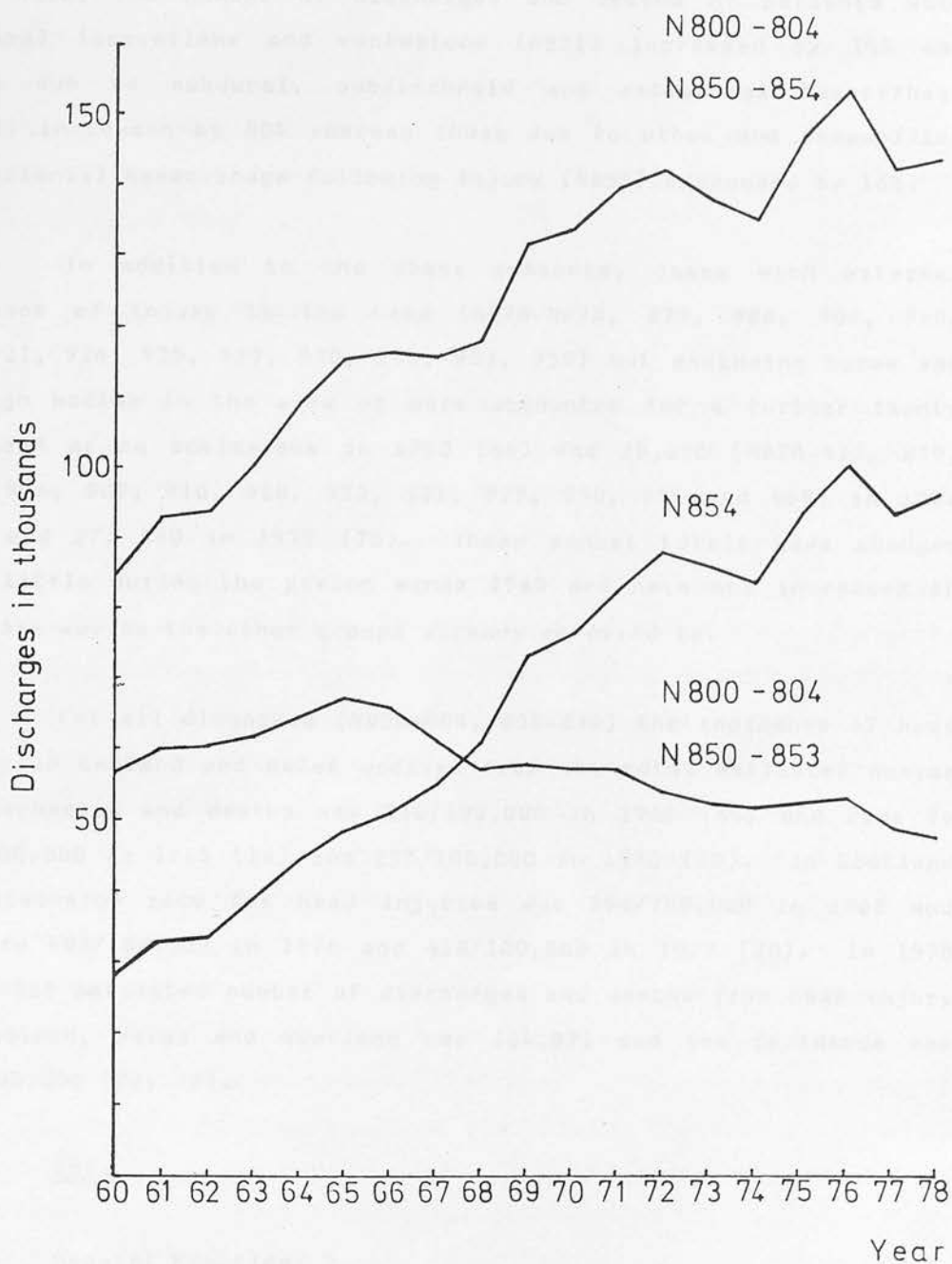


Figure 2.1 Total estimated Head Injury discharges and deaths: England and Wales 1960 - 1978

(N801) remained fairly constant. Additionally other and unqualified skull fractures (N803) decreased by 66% and multiple fractures involving the skull or face with other bones (N804) decreased by 80%. Also, the number of discharges and deaths of patients with cerebral lacerations and contusions (N851) increased by 14% and those due to subdural, subarachnoid and extradural haemorrhage (N852) increased by 80% whereas those due to other and unspecified intracranial haemorrhage following injury (N853) decreased by 16%.

In addition to the above patients, cases with external evidence of injury to the head (N870-N873, 879, 900, 904, 910, 918-921, 924, 925, 929, 950, 951, 957, 959) but excluding burns and foreign bodies in the eyes or ears accounted for a further twenty thousand or so admissions in 1960 (66) and 28,690 [N870-873, 879, 904, 906, 907, 910, 918, 920, 921, 929, 950, 951 and 959] in 1974 (71) and 27,840 in 1978 (70). These annual totals have changed very little during the period since 1960 and have not increased in the same way as the other groups already referred to.

For all diagnoses (N800-804, 850-854) the incidence of head injury in England and Wales derived from the total estimated number of discharges and deaths was 210/100,000 in 1962 (66) and rose to 244/100,000 in 1968 (14) and 293/100,000 in 1978 (70). In Scotland the discharge rate for head injuries was 294/100,000 in 1968 and rose to 403/100,000 in 1978 and 418/100,000 in 1979 (20). In 1978 the total estimated number of discharges and deaths from head injury in England, Wales and Scotland was 164,871 and the incidence was 304/100,000 (70, 72).

2.1.2 AGE:

a) General Practice:

The Second National Study of General Practice (1970-71) in England and Wales (46) showed that the age-distribution of patients was skewed to the left. For females the age-specific incidence declined steadily from a peak at 0-4 years (190/100,000), until a

further rise occurred in those aged 75 years and over (110/100,000), with a minor peak at 15-24 years (120/100,000). For males three peaks were evident, the first, and second highest, occurred at 0-4 years (220/100,000), the highest at 15-24 years (400/100,000) and the third and lowest in those aged 75 years and over (160/100,000). Approximately 59% of males and 55% of females were under 25 years. Perkin's study (47) confirmed the skewness of the age-distribution with 60% of his patients being aged less than 16 years and 80% less than 30 years of age.

b) Accident and Emergency Departments:

Reports covering all A&E attendances are confined to four, (17, 18, 19, 52), Jennett et al (17) reported a third of patients were less than ten years of age, 54% less than twenty years and 6% over sixty-four years. Strang et al (18), reporting on all Scottish hospitals and including those reported by SHIMS (17), found that 43% were less than fifteen years old and 63% less than twenty-five years with 6% aged sixty-five years or over. In a brief report from Newcastle, two hundred and twenty-one mild head injuries (N800, N850, N910, N920) and patients with symptoms following head injuries presenting in a four week period in January, 1977 were identified (52). It is difficult to determine the exact age-distribution from the information provided, however about 37% were aged 0-15 years.

Jennett and MacMillan (19) reported age-specific attendance rates for A&E departments. For males, these declined slowly from a peak at 0-4 years (approximately 4300/100,000) with a minor rise at 15-24 years, to a minimum at 65-74 years (1000/100,000) followed by a slight rise at 75 years and older. In females the initial decline from a peak at 0-4 years (approximately 3300/100,000) was much more rapid with a minimum at 55-64 years (approximately 420/100,000), followed by a slight rise at 65-74 years and continued upward in those aged 75 years and over. Swann et al (50) included only those 13 years and older in their study of an inner city A&E department, nevertheless, 33% were aged 15-24 years and 9% were over 65 years.

c) Admissions:

For those series covering admissions of all ages, Rowbotham et al (42) reported 23% of two thousand patients were less than 12 years old, and for the latter fourteen hundred this percentage rose to 29%, while 42% were aged 20 years or less and 11% were over 60 years of age. Steadman and Graham (45) classified three hundred and ninety of their four hundred and eighty-four patients by age and found approximately 43% were aged 0-20 years. In Scotland 23.5% of five hundred and thirty-two admissions were aged 0-10 years and the same percentage were aged 11-20 years, while only 4.3% were over 70 years (53). In England and Wales in 1972, 14% of head injury admissions were aged 0-4 years, 24% 5-14 years and 13% 15-19 years (14). In Scotland, excluding the Lothians, in 1974, 36% were less than 15 years and 9% more than 64 years old (17) while more than two thirds were less than 45 years (25).

Jennett and MacMillan (19) determined the age-specific admission rates for head injury in 1974 in Scotland and in England. For Scottish males the rate rose from approximately 650/100,000 in 0-4 year-olds to a maximum of approximately 900/100,000 in 15-19 year-olds, thereafter declining to a minimum of approximately 300/100,000 in 65-74 year olds, before rising slightly again in those 75 years old and over. The age-specific admission rates for Scottish females declined steadily from a maximum of approximately 450/100,000 in 0-4 year-olds to a minimum of approximately 100/100,000 in 35-64 year-olds before rising again in those aged 65-74, and continuing to rise in those aged 75 years and over. The situation in both males and females in England was broadly similar although in English females there was a more marked minor peak in 15-19 year-olds and a drop in 5-14 year-old males.

Series covering adult admissions only, still show a bias toward youth. In the study of patients aged 15 years and over reported by Kerr et al (33), 43% were aged 15-29 years, 8.6% were 70 years old and over. In Galbraith's series (16) of nine hundred and eighteen admissions over 11 years of age, about 21% were aged 12-19

years, 19% aged 20-29 years and 8.7% aged 70 years and over. A recent series from Scotland has an age-distribution intermediate between an unselected group of admissions of all ages and a group of adult admissions (73). Thus only 12% of the direct admissions to the head injury unit at Edinburgh Royal Infirmary in 1979 were under 15 years old.

Burkinshaw (60) studied two hundred and thirty-eight children under 14 years of age admitted because of head injury in the years 1951-56 inclusive. He defined head injury clearly, but excluded patients with simple incised wounds and no symptoms of concussion, wounds of the face and eyes only with no symptoms of concussion, and any patient with multiple injuries unless they fulfilled the stated definition of head injury. He also admitted to the probability that the admission criteria were not uniform during the study period and that some injuries, particularly severe injuries, would have gone elsewhere. In both males and females the age-distribution peaked between 8-9 years with lesser peaks at 12-13 and 4-5 years in boys and at 4-5 years in girls, although the number of boys and girls at each year of age was small.

A retrospective study of head-injured children admitted in Sheffield during the seven years up to the end of 1958 yielded eleven hundred and eighty children aged less than fourteen years (63). Head injury was defined, although some of the patients included may have been admitted for injuries other than to the head. Dividing the patients into classes with a unit class-width of one year produced fair sized samples at each year of age with a range of 29-86 in boys and 5-38 in girls. For boys, a peak occurred at 6-9 years, whilst in girls the incidence rose to a peak at 3 years and then steadily declined.

Eight hundred and fifty-seven Newcastle children with head injury were admitted to hospital during 1967-69 (62). The definition of head injury used to select these patients was very similar to that used by Burkinshaw. Twelve children with non-accidental injuries were excluded from this retrospective study,

while 18% were secondary referrals and were included if they were admitted to the receiving hospital within twenty-four hours of their accident. Again the children were divided into classes with a unit class width of one year. The major peak in both males and females occurred at 6-7 years, lesser peaks occurring in boys aged 3-4 years and 9-10 years, while in girls lesser peaks occurred at 2-3 years, 4-5 years and 8-9 years. The situation in Newcastle was again studied, this time prospectively, for three and a half months commencing on the first of November, 1971 (61). All head injury admissions and those admitted with multiple injuries who had a severe head injury were included. Head injury was not further defined and the admission criteria were not stated. Two hundred children were admitted during this period, 5% were secondary referrals and the age range was nine days to fourteen years and seven months. Boys peaked at 6 years of age with minor peaks at one year and 10 years. For girls, the main peak occurred one year earlier than in boys, with a lesser peak at one year and a small peak at 9-10 years and again at 12 years of age.

d) Neurosurgical Units:

In Mersey Region in 1975-76, 17% of patients transferred to the NSU were in the first decade of life, 18% in the second decade, rather fewer than the age-distribution of admitted head injuries would suggest (56). Succeeding decades showed a continuing downward trend interrupted by a slight rise in the sixth and seventh decades. Immediately before this period, of patients transferred to three Scottish neurosurgical units, 25% were under 15 years of age and 66% were aged 15-64 years (17).

Children with serious head injury admitted for more than three days in Newcastle in 1974-75 and who were aged 3-14 years were studied retrospectively by Moyes (64). Four children with incomplete information were excluded, leaving eighty-seven children. Peak incidence was at 10 years with lesser peaks at 3 years and 7 years.

In summary head injuries are commonest in young people of both sexes, no matter how selected the population. This preponderance of youth becomes less marked as the proportion with more serious head injuries rises. Thus of General Practice patients, 60% are under 16 years of age (47), of A&E patients 43% are under 15 years of age (18), of admitted patients 36% are under 15 years (17) and in neurosurgical units 25% of patients are under 15 years old (17). Other workers confirm these mostly Scottish results, thus in A&E 37% of patients were less than 16 years old (52), for admitted patients 42-51% were aged less than 20 years (14, 42, 45, 53) and of those transferred to neurosurgical units, 35% were aged less than 20 years (56). SHIMS (17) showed that this trend in age proportion was statistically significant. Age-specific rates peak at 0-4 years in A&E attenders of either sex and at 15-19 years for male admissions and 0-4 for female admissions (19). Considering children's admissions only, the main peak in incidence occurs at 6-9 years for both sexes with lower peaks at 4 years and 10 years in boys and 4 years and 9 years in girls (60, 61, 62, 63) while for more serious injuries a peak occurs at 10 years with lesser peaks at 3 years and 7 years. (64).

These general points are confirmed by a consideration of national statistics for England and Wales and for Scotland. Results from the Hospital In-patient Enquiry (England and Wales) 1973 (74) indicated that of patients with fractures of the skull or face (AN138) 26% were aged 0-14 years, 68% were 15-64 years and 5.7% were sixty-five years or more. For patients with intracranial injury without fracture (AN143) the proportions were 40%, 50% and 9.4% respectively. Among children with fractures of the skull and face only, 40% were aged 0-4 years, 27% were aged 5-9 years and 34% were aged 10-14 years and among children with intracranial injury without fracture the proportions were 32%, 40% and 28% in the same age groups. These differences with age in about the same proportions were also evident from other national statistics for England and Wales (67, 68, 69, 70, 71). In Scotland in 1975, 33% of all head injury discharges were aged 0-14 years, 59% were aged 15-64 years and 8.1% were aged sixty-five or over (75). By 1979 these

proportions had altered to 30%, 61%, and 9.1% respectively (20).

Patients included in each more specific diagnostic category showed characteristic differences depending on their age and sex. Vault fractures were commoner in children, especially girls under five years old and fractures of the base were commoner in adults, particularly women of sixty-five years or more (69, 71). Facial bone fractures were uncommon among children in general, but especially in those under five years of age and were most common in young adults. Thus 76% of male and 61% of female patients admitted because of facial fractures were aged 15-44 years, whereas 0.3% were boys aged 0-4 years and 3% were girls of the same age (71). Other and unqualified skull fractures (N803) were almost evenly distributed between the different age-groups: 0-4, 5-14, 15-44, 45-64 and 65+ indicating an under-representation of young adults with this type of injury and an over-representation of children and the middle-aged and elderly. The age-distribution of multiple fractures of the skull or face with other bones (N804) indicated under-representation in children and young women and over-representation in the middle aged and elderly. Only about 10% of patients admitted with this type of injury were under fifteen years whereas almost one third of males and nearly three fifths of females were over forty-four years old (71). In Scotland in 1975 15% of male and 12% of female head injury admissions had fractures of the facial bones and showed the same overall relationship of incidence to age as in England and Wales (75). In 1979 the proportions were 15% in males and 11% in females (20).

Age and sex determined patterns were also apparent among those patients with intracranial injury without skull fracture (N850-854). The age-distribution of patients with concussion (N850) was similar to the overall age-distribution in patients without fracture (69, 71). Cerebral lacerations and contusions (N851) were over-represented in young and middle-aged adults and under-represented in children, except for girls under five years of age (71). In elderly patients such injuries were slightly over-represented in males and under-represented in females.

Intracranial bleeding (N852) was over-represented in patients aged 0-4 years and much under-represented in children of both sexes aged

ICD CODES		AGE GROUPS				
		0-4 %	5-14 %	15-44 %	45-64 %	65+ %
N800	M	27	24	30	11	7.7
	F	46	29	9.4	7.1	8.2
N801	M	17	27	34	16	6.1
	F	15	28	25	9.7	22
N802	M	0.3	12	76	9.1	2.7
	F	3.0	14	61	14	7.3
N803	M	22	24	20	26	7.1
	F	25	17	23	19	17
N804	M	2.4	7.1	60	17	14
	F	5.3	5.3	32	21	37
N800-N804	M	7.9	16	60	11	4.5
	F	13	18	45	13	11
N850	M	8.3	25	51	11	4.7
	F	13	22	36	13	15
N851	M	2.3	21	51	19	7.0
	F	20	6.7	40	20	13
N852	M	15	2.5	38	20	25
	F	19	9.7	9.7	26	35
N853	M	42	8.3	25	25	0
	F	0	33	33	17	17
N854	M	13	30	41	10	6.1
	F	18	26	28	10	18
N850-N854	M	12	28	43	11	6.1
	F	17	25	30	11	17
TOTAL	M	11	26	47	11	5.8
	F	16	24	32	12	16

Table 2.2 Distribution of numbers in the sample for England and Wales 1974 by age-group and ICD code.

5-14 years and in young women, but was over-represented in middle-aged and elderly patients and to a lesser extent in young men (71). Other intracranial bleeding (N853) followed a similar pattern in children to that for mass lesions (N852) except that girls aged 5-14 years were over-represented (71). In adults, young men (15-44 years) and elderly men (65+ years) were under-represented and middle-aged men (45-64 years) were over-represented as, to a lesser extent, were young and middle-aged women. The remarks concerning patients included in rubrics N851-3 must be weighted by the small sample sizes involved. Cases with other and unspecified intracranial injury (N854) showed an age-distribution similar to that for all patients with intracranial injury without skull fracture with a slight over-representation in children (71). These age dependent differences for 1974 are shown in Table 2.2

2.1.3 SEX:

a) General Practice:

The male/female ratio for these patients was 2.0 overall (46). The age-specific incidence in males and females has already been described in the preceding section.

b) Accident and Emergency Departments;

For all ages the male/female ratio was 2.4 (17). In the under fives, boys and girls were almost equally represented but the ratio of males to females in the 15-24 year age group was 4.0 and this ratio decreased with increasing age approaching unity in those aged 65 years and over (18). Maitra (52) reported a male/female ratio of 3:1 among 16-50 year olds but only 1:11 in patients over 65 years not admitted. In an inner city A&E department the ratio was 3.2 for patients 13 years and over (50).

c) Admissions:

Papers dealing with all age groups show the same male

preponderance. In 1945-51 this was 3.5 (42), and in 1958 it was 2.6 (45) while in a mixed urban and rural area of Scotland in 1957-61 it was 3.8 (53). For the whole of England and Wales in 1972 the male/female ratio was 2.0 (14) and for Scotland two years later it was 2.3 (17). For adult populations the ratio varied from 4.4 in Newcastle in the early 1960's (33) to 2.5 in Glasgow in 1973-4 (16). Kerr's study (33) included 20% of the total as secondary referrals.

Among childhood admissions following head injury the ratio was 3.3 (60), 2.3 (63), 2.1 (62) and 1.9 (61), each of these studies reported a period later than the preceding figure. Partington (63) calculated the significance of the ratio at different ages based on the known proportion of each age in the population of Sheffield at the time, and concluded that the excess of boys was not significant until over the age of one year. After the age of 2 years the ratio of boys to girls increased steadily with age from 1.4 at age 3 to 5.3 at age 11 years.

The male/female ratio is much nearer to unity in young patients of 0-4 years, whilst for patients aged 75 years and over the overall ratio is reversed as one would expect since females then outnumber males in the general population (14). The ratio is greatest for ages 20-24 years when the male/female ratio is 3.6, at 15-19 years it is 2.7 and at 25-34 years it is 3.2 (14). When age-specific rates in England and Wales are considered the lower sex ratio at younger ages is confirmed but the reversal of the ratio in the older age group is restored so that the male/female ratio is again greater than 1 (19). The ratio is highest at age 20-24 years when it is 3.6 (19).

d) Neurosurgical Units:

For these more serious injuries the ratio was 3.5 for all ages in Scotland in 1974 (17) and 2.9 in Mersey Region in 1975-76 (56), while for children under 15 years in Scotland in 1974 it was 5.0 (17) and at about the same time in Newcastle children

aged 3-14 years was 3.8 (64). In an adult study it was 3.5 in Newcastle in 1959 (65).

All studies whether of General Practice, A&E or admitted patients, confirm a male preponderance with a male/female ratio of at least 2:1. The male excess is less marked in General Practice (46) and most marked in neurosurgical units (17, 56), with A&E patients and admitted patients both about the same (17) and intermediate between the two, although nearer to the ratio in General Practice. At the extremes of life the ratio approached 1 and this applied equally to General Practice (46), A&E (18) and admitted patients (14). In General Practice, A&E and admitted patients the highest ratio occurs in 15-24 year olds (14, 18) or 20-24 year olds (14). In neurosurgical units the ratio is very high in the under 15 age group (5.0) with an overall ratio of 3.5 (17).

These ratios and trends indicate that apart from head injuries being commoner in males, more severe injuries are even more common particularly in young males. There are probably many reasons why this should be so including the fact that males are more likely to work in jobs associated with higher risk, to be involved in sport, to drive motor cycles and cars and to be involved in assaults. Biological, social and psychological factors which operate on males in our society may also help explain the male excess in head injuries since they combine to increase risk-taking behavior (33).

In the Hospital In-patient Enquiry: England and Wales 1962-67 (66) the male/female ratio of the numbers in the sample for head injury admissions rose from 1.50 in children under one year to 3.04 in children aged 13-14 years. In 1973 the ratio for cases with fractures of the skull and facial bones (AN138) rose from 1.26 to 2.50 in the same age groups and for patients with intracranial injury excluding skull fracture (AN143) from 1.57 to 2.26 (74). From 1973 to 1978 the sex ratio of the numbers in the whole sample of head injuries was 2.40 or greater (range 2.40 - 2.78) for patients with fractures of the skull or facial bones (N800-804) (67,

68, 69, 70, 71, 74). During the same period the ratio for patients with intracranial injury without skull fracture (N850-854) had consistently been less than 2.00 (range 1.76-1.89). For patients with fracture, the ratio was highest among 15-19 year olds (4.08 in 1978) and rose from 1.38 in 0-4 year olds to this level, thereafter fell before rising to 3.90 in 35-44 year olds and falling to 0.78 in patients over sixty-four years (70). Also in 1978 but among patients without skull fracture the ratio increased from 1.32 in 0-4 year olds to 2.87 in 20-24 year olds and then steadily fell to 0.58 in patients over sixty-four years (70). For each succeeding year from 1973 to 1975 the ratio among patients with skull or facial bone fractures increased in patients aged 0-44 years but fell in patients over forty-four years (67, 71, 74). At the same time the ratio among patients without fracture decreased in children and increased in patients over forty-four years (67, 71, 74). From 1976 changes in the male/female ratio have not followed any definite pattern, although a decline in the ratio in children aged 0-4 years without fracture and an increase in patients aged 15-44 years with fracture was apparent (68, 69, 70).

The ratio of the samples of males and females also varied with the sub-groups of injury. In 1974 the ratio in adults aged 15-44 years with vault fractures was 9.75 (71) but in 1977 was 4.40 in the same age group and 14.0 in 45-64 year olds (69). In both these years the ratio in patients with vault fractures was higher in patients over sixty-four years (2.86 + 3.43) than in all patients with fractures of the skull and facial bones who were over sixty-four years (1.08 + 1.15) (69, 71). However in 1978 the ratio in patients with vault fractures who were over sixty-four years was 0.77 compared with a ratio of 0.80 for all patients with skull and facial fractures (70). In general the ratio in patients with vault fractures has fallen in 5-14, 15-44 and 65+ year olds since 1974 (67, 68, 69, 70, 71). In cases of basal fractures the ratio has fallen in 0-4, 15-44 and 45-64 year olds and increased in patients over sixty-four years. For facial fractures the ratio has increased in 0-4 and 15-44 year olds and decreased in 5-14 year olds and patients over sixty-four years. The ratio in patients with other

and unqualified skull fractures has increased in 15-44 year olds from 1.67 in 1974 to 5.63 in 1978 and for patients with multiple fractures has increased from 1.75 to 3.33 in 45-64 year olds (70, 71). No consistent pattern was observed in other age groups. In concussed patients the sex ratio increased in patients aged 15-44 and 45-64 years between 1974 and 1978 (69, 70, 71). Among patients with other and unspecified intracranial injury (N854) the ratio fell in each adult age-group and increased in children aged 0-4 years.

In 1975 in Scotland the overall sex ratio for all head injury discharges was 2.4 (75). In 0-4 year olds the ratio was 1.4, rose to 3.4 in 15-44 year olds and fell to 1.1 in patients over sixty-four years. Four years later the overall ratio was 2.3 (20). However the ratio in 0-4 year olds had increased to 1.5 and rose to 3.3 in 15-44 year olds before falling to 1.0 in patients over sixty-four years old.

2.1.4 SOCIAL CLASS:

This characteristic of head-injured patients has only occasionally been studied. No publications discuss the relationships between social class and head injuries seen in General Practice or in A&E departments. Only four recent British publications consider this aspect of the problem at all. Steadman and Graham (45) classified the 80% of their total number of patients (484) who lived within the boundaries of Cardiff City Borough, by age and social class. They concluded that only in social class IV, which was over-represented, were any significant differences apparent.

Field (14) compiled a table (from unpublished data for all adult hospital admissions for head injury in Oxfordshire during the mid 1960's) relating social class to age for adult males over fourteen years old. The definition of head injury used was that included in ICD (7th revision) rubrics N800, N801, N852, N854 and N855 only, a more selected group than that chosen by Field himself (N800-804, N850-854 8th revision). Between the ages of 20-64,

social class V was heavily over-represented and social classes I and II were under-represented. The over-representation of social class V was most marked in the young to middle-aged and especially for those aged 35-44 years, when four times the predicted number of patients of social class V were admitted. Similarly, only 40% of the predicted number of admissions aged 45-54 years from social class I were admitted. Under-representation of social class II was most marked in 55-64 year olds (48% of predicted). Overall, social class III was slightly over-represented, but under-represented in males aged 35 and over. Social class IV was under-represented overall except for males aged 25-34 years when there was no marked difference between actual and predicted numbers. For other ages the under-representation became less apparent as age increased.

Kerr et al (33) also studied an adult population of head injury admissions of both sexes, although 20% of the total were secondary referrals. They also found social classes I and II under-represented and social class V over-represented while they found social class III under-represented, and social class IV over-represented, which was the opposite to Field (14), but similar to Steadman and Graham (45). Relating social class to cause of injury, they found assault and domestic accidents (both associated with alcohol) more common in social class V; industrial accidents commoner in social class IV and accidents during sport and recreation commoner in social classes I and II. Road traffic accidents were less common in social classes I, II and III than expected from their distribution in the general population, and commoner in social classes IV and V.

In studying a group of children in Newcastle admitted because of head injury, Jamison and Kaye (62) determined the social class distribution of these patients and compared this with the distribution in a control group of four hundred and eighty-six consecutive paediatric admissions. They concluded there was no significant relationship between social class and head injury admission. This statement may however, not be true if the social class distribution of children admitted with head injury is compared

with the distribution in the general population rather than with another selected population. Also, 18% of the head-injured group were secondary referrals and twelve babies with non-accidental injuries were excluded. Also in Newcastle, but this time considering only the survivors aged 3-15 years of more severe injuries, Moyes (64) found no major differences from the social class distribution of the general population of the Newcastle Regional Hospital Board or of the city of Newcastle. Survivors represented 85% of an already highly selected group.

In summary, in adult patients admitted because of head injury, social classes I and II were under-represented while social class V was over-represented (14, 33), especially in the 35-44 year age group (14). Assaults and domestic accidents were commoner in social class V, industrial accidents commoner in social class IV and sporting and recreational accidents commoner in social classes I and II (33). Road traffic accidents were commoner in social classes IV and V than expected and less common in social classes I, II and III (33).

2.1.5 CIVIL STATE:

Steadman and Graham (45) were unable to find any significant trends in relation to marital status. Kerr et al (33), however, found an excess of single and a deficit of ever-married among their patients, although this was found to be not significant when corrected for age. Divorced patients were four times as common as predicted, a highly significant result (33).

In England and Wales from 1964 to 1967 in adults the ratio of married patients with head injury to single, widowed or divorced patients was amongst the lowest for all diagnostic categories (66). In women the ratio increased with age to a maximum of 0.97 in those over sixty-four years. In 1973 and 1978 the ratio of married patients to others for diagnostic groups AN138 and AN143 was lower in males than females in each age-group from 15-44 years and thereafter was higher (70, 74). The latter difference was most

marked in patients over sixty-four years. In 1973 the maximum ratio among males included in rubrics AN138 occurred in 45-64 year olds (2.7) and in women in 35-44 year olds (3.9) (74). In 1978 the maximum ratio (2.4 males and 2.7 females) occurred in 45-64 year olds (70). For patients included in rubrics AN143 the maximum ratio in both sexes in 1973 occurred in 35-44 year olds (2.3 male and 4.6 female) (74) and in 1978 in males occurred in 45-64 year olds (2.0) and in females in 35-44 year olds (2.4) (70).

2.1.6 PREDISPOSITIONS AND ASSOCIATIONS:

Over-representation of some patients by virtue of their age, sex or social class has already been detailed. This section deals with other features which may be overly associated with head injury.

An estimate of the overall incidence of epilepsy (more than one non-febrile convulsion) for the United Kingdom was 50/100,000, while the prevalence was estimated by the same author as 700/100,000 in those aged less than sixteen years and 350/100,000 in adults (76). Since about 40% of head injury admissions are aged less than sixteen years the prevalence of epilepsy in a group of head injury admissions of all ages could be expected to be about 0.5%. Kerr et al (33) found a history of epilepsy in 2.1% of their group of patients, although only three of the ten patients with such a history had sustained their head injury during a fit. In the small sample from Newcastle only one (2.7%) of thirty-seven A&E attenders who were admitted because of head injury suffered from epilepsy (52). Several British workers have suggested a high proportion of previously maladjusted individuals among head-injured patients although they were dealing with highly selected populations (33, 38, 65).

The relationship between alcohol and head injury has been widely studied. A prospective study of all head injuries (N800, N801, N803, N850-N854) admitted to the Western Infirmary Glasgow for the year ending 31st August, 1974 has been reported on

(16). All patients were aged twelve years or more and the male/female ratio of the nine hundred and eighteen consecutive admissions was 2.5. All patients had their conscious level assessed by the Glasgow Coma Scale and blood alcohol estimations on admission. The latter findings have been reported separately (77). All blood alcohol levels greater than 5mg% were considered evidence of recent alcohol consumption. On Fridays and Saturdays, 62% of patients admitted had a detectable blood alcohol level, compared with 43% of those admitted during the remainder of the week. This difference was highly significant, as was the fact that a detectable alcohol level was more than twice as common in men (62%) as women (27%). The mean alcohol level in patients with positive tests was 193mg% for men and 165mg% for women. Alcohol was significantly more often associated with head injuries due to assaults and 'falls under the influence' in both sexes and the mean levels were also significantly higher. Among the victims of road traffic accidents, detectable alcohol was twice as commonly found in male pedestrians as in other male traffic accident victims and the mean level was twice as high in pedestrians.

Of four hundred and seventy-six patients with detectable alcohol levels, two hundred and eighty-five (60%) were fully conscious, one hundred and thirty-four (28%) were disorientated and fifty-seven (12%) were in coma. Significantly more patients in coma had a serious head injury as compared with those who were fully conscious or disorientated. For those without a serious head injury the blood alcohol was significantly higher in disorientated and comatose patients than in fully conscious patients. Attributing a depressed conscious level to a patients drunkenness often leads to delay in the diagnosis of complications following head injury (78). Galbraith et al (77) were unable to correlate the conscious level with a definite blood alcohol. However, patients without serious head injury but with a depressed conscious level all had blood alcohol levels around 200mg%. Thus a depressed conscious level in a patient with a blood alcohol less than 200mg% should not be attributed to drunkenness.

Holt et al (79) reported their findings from a sample of A&E attenders presenting between 17.00 and 09.00 hours on seventeen different days between March and November, 1979 (8 Friday evenings, no Sundays or Tuesdays, 1 Monday, 3 Wednesdays, 3 Thursdays and 2 Saturdays). All consecutive attenders had their recent alcohol consumption assessed clinically and using an Alcolmeter. Only two patients were excluded, for lack of co-operation, and seven hundred and two adult patients were so studied. Overall, 40% (48% male and 27% female) had recently consumed alcohol and 32% had a blood alcohol greater than 80mg% (17.4 mmol per litre). For thirty-seven head-injured patients (head injury not defined) 54% had a positive alcolmeter test and nineteen of these twenty patients had a blood alcohol more than 80mg%. The mean blood alcohol for the twenty patients was 200mg% (43.4 mmol per litre). 47% of all RTA victims tested, 86% of all assaults, 53% of all patients with major injury and 44% of all patients with minor injury as well as 74% of all self-poisonings had a positive test. These results are from a very highly selected (by time of day and day of week) group of A&E attenders but are nevertheless salutary. At the same hospital, 42% of all direct head injury admissions during the whole of 1979 had clinical evidence of alcohol intoxication (73).

Rutherford (80) reported on one hundred and thirty-seven consecutive patients with mild head injury (undefined) admitted for observation. 83% of these had both a clinical assessment of their alcohol intake and a blood level measurement. 42% of those tested had a positive result for blood alcohol and in 88% of these the result was more than 100mg%. At all levels of blood alcohol, including those greater than 300mg%, false negative results, admittedly by very junior doctors, were high, e.g. for six patients with blood alcohol levels from 1-99mg%, five were assessed clinically as not having ingested alcohol, the lowest number of false negatives (10%) occurred in twenty patients with blood alcohol levels between 200-299mg%.

In Newcastle in 1977, 22% of thirty-seven patients of all ages admitted from A&E following head injury had clinical

evidence of excessive alcohol consumption compared with 2% of one hundred and eighty-four attenders with head injury not admitted (52). SHIMS (17) reported recent consumption of alcohol in 22% of A&E attenders over fourteen years of age, with a significantly higher proportion in both patients admitted to primary surgical wards and in patients admitted to neurosurgical units. Also discussing A&E attenders, Strang et al (18) noted urban and rural differences in alcohol consumption. 26% of A&E attenders with head injury at city hospitals were noted to have recently consumed alcohol compared with 20% of attenders within thirty miles of cities and only 15% of those attending at more distant A&E departments. These proportions were significantly different. Recent alcohol consumption was most common in men who had fallen. In women it was most often associated with assault. For road traffic accidents recent alcohol consumption was commoner in pedestrians than vehicle occupants, a result previously reported by Kerr (33) and Galbraith (77). In addition, recent alcohol consumption was twice as common in A&E attenders who were admitted as in those discharged.

In a prospective study of A&E attenders aged thirteen years and over at an inner city A&E department, 46% of all attenders and 71% of assaults had recently consumed alcohol, whereas 57% of those admitted had recently consumed alcohol (50). This latter figure is somewhat higher than that found by MacMillan et al (25) (38%) in a study of all head injury admissions in Scotland. Recent alcohol consumption was more than twice as common in adult males as in adult female admissions. Kerr et al (33) reported alcohol consumption in 29% of male and 10% of female admissions. They concluded that alcohol may be responsible for half of all adult domestic accidents and assaults causing head injury and a fifth of all road traffic accidents.

Irwin, Patterson and Rutherford (81) reported their findings on fifty consecutive pedestrians using breath samples and an alcolmeter, except for eight patients with serious injuries who had blood alcohol levels measured. A control group of fifty patients was also analysed. The mean alcohol in the injured

patients who had been drinking (46%) was 170mg% (36.9 mmol per litre), range 60-340mg% and in the controls who had been drinking (24%) was 92mg% (20 mmol per litre) with a range 30-180mg%. Using the Injury Severity Score (35) a significant correlation was shown between more severe injury and higher blood alcohol levels. Not all these patients will have had head injuries, indeed this particular aspect was not the subject of the study, however, many would have had head injuries.

Summarising, recent alcohol ingestion occurs in 20-25% of all adult A&E attenders with head injury and 40% of adult admissions. It is more than twice as common in males as females and is particularly associated with assaults and falls. The proportion of admitted patients with recent alcohol consumption is significantly higher than the proportion of A&E attenders and the proportion of patients admitted to neurosurgical units is significantly higher than the proportion of patients admitted to primary surgical wards.

Authors of several papers describing head injuries in children admitted to hospital have sought association with personality or accident-proneness. Partington (63) has investigated the importance of accident-proneness by comparing a group of eleven hundred and eighty children with head injury, collected retrospectively, with a small group of thirty head-injured children and a control group of thirty acute medical cases, in whom a more detailed past and family history was known for all types of accident. The seventy-six in the main series with a past history of any accident were significantly different from the overall group in terms of sex ratio, the excess of boys being significant. A significant male excess of past injury was also found in the smaller group of sixty patients. Nineteen of the larger group had forty-four head injuries between them and these were significantly more often due to falls than in the rest of the series. He was not able to show any evidence of accident-proneness. Family size was significantly larger in the small head-injured group compared with the control group.

Craft et al (61) used a Rutter teacher assessment form for their group of children and found significantly more children with head injuries had a higher score than a control group. They took this to indicate that predisposing characteristics may be identifiable, although doubted that identifying them would lead to any useful preventative measures. 18% of their children with head injury who were of school age were left handed compared with a national incidence of 6%. Adelstein (82) discussing fourteen hundred and fifty-two accidents of a general nature among railway shunters concluded that accident-proneness was more important in damage to property than damage to person. In Moyes (64) highly selected group of children, family size was not found to be related to the occurrence of head injury, but children with head injury were of significantly higher birth order. Lack of available local data prohibited the relationship of marital status and working mothers to head injury being determined, although it was suggested by the results that children of single parent families were more prone to severe head injury.

2.1.7 CAUSES:

Division of civilian head injury into missile and non-missile groups would clearly yield one very large and one very small group. Similarly, division into those caused by the dissipation of mechanical energy, thermal energy etc., is for practical purposes worthless. Lack of any clear-cut and obvious categorisation of causes of head injury has led to most authors using different systems of classification, which makes comparisons between different series more difficult. A commonly used classification, with varying modifications and refinements, breaks down causes into geographical (home, work, road, school) and mechanism (fall, fall from a height, fall from a bicycle). Assaults are often a separate group while non-accidental injury is a special type of assault limited by the age of the patient.

a) General practice:

In Perkin's study (47), home injuries accounted for 46%, road traffic accidents 39% and industrial injury 16%. 14% of domestic and 53% of road traffic accidents were admitted.

b) Accident and Emergency Departments:

Once again nearly all the British work detailing patients of all ages, comes from studies in Scotland (17, 18, 19). The only study of adults, also originates from Scotland (50). These studies are summarised in Table 2.3.

AUTHOR & STUDY YEAR	AGE RANGE & No. OF PATIENTS	RTA	HOME	WORK	SPORT	FALL	ASSAULT	OTHER
SHIMS 1974	ALL AGES 3035	18%		6%	11%		12%	
STRANG ET AL 1974	ALL AGES 3558	18%	18%	8%	12%	14%	16%	15%
MAITRA 1977	ALL AGES 221	9%				56%	17%	19%
SHIMS 1974	15 + 1700			10%			22%	
SWANN ET AL 1978	13 + 784	12%	6%	10%	5%	28%	33%	6%

Table 2.3 Causes of injury among A&E attenders.

Among these overall figures some trends are discernible. Home accidents were commoner in those under fifteen years of age and over sixty-five years, whilst falls were commoner in the elderly (18). Road traffic accidents were less common in children (9%) than in adults (24%), children being more often injured as pedestrians (66%), and adults more often as vehicle occupants (71%) (18). Assaults nearly always occurred in those aged 15-64 years (18). In

children, sex made little difference to the cause of the head injury while in adults, assaults were more common in men and home accidents commoner in women (18). In an urban adult population of A&E patients, assaults accounted for 33% of patients while road traffic accidents accounted for only 12%, yet 50% of road traffic accident victims were admitted as against 27% of assaults (50). 21% of admissions arose from road traffic accidents, 31% from assaults and 31% from falls. The percentage of assaults in this series is 50% higher than in the series for the whole of Scotland excluding the Lothians.

c) Admissions:

Papers relating to admitted patients will be considered according to the ages studied: all ages, adults only and children only. The following table (2.4) summarises the results of those papers dealing with all age-groups and is presented in chronological order. Before discussing the results it is worth considering the findings in a thousand consecutive head injury admissions presented by Lewin (43). Although no ages are specified for this group, 75% were due to road traffic accidents, 8.5% occurred at play, 6% in the home, 5% at work and 6% were due to other causes. These figures are for a period which overlaps with that of Rowbotham's study (42) yet are markedly different, particularly in regard to the proportion due to road traffic accidents and industrial accidents. Presumably the occurrence of more heavy engineering and coal mining in Newcastle compared to Oxford would account for the larger percentage of industrial accidents in Rowbotham's series. More than twice as many pedestrians appeared in the Newcastle series (45%) as in the Oxford series (22%) while the proportions for car occupants, motor cyclists, pillion-passengers and cyclists were 50% higher in Oxford. Since the Oxford series does not give the age-distribution of its patients and neither defines head injury nor admission policy, further discussion of the two papers is speculative.

Considering all ages together, (Table 2.4) road traffic accidents are consistently the commonest cause of head injury,

AUTHOR AND STUDY YEAR	NUMBER OF PATIENTS AND AGE RANGE	RTA	HOME	WORK	SPORT	FALL	ASSAULT	OTHER
ROWBOTHAM ET AL 1945-51	1400 ALL AGES	42%	6%	22%	3%	18%	2%	7%
STEADMAN & GRAHAM 1958	484 ALL AGES 7% secondary referrals	45%	14%	9%	3%		7%	19%
BARR & RALSTON 1957-61	532 ALL AGES	67%	12%	9%	11%		2%	
SHIMS 1974	1181 ALL AGES	34%		4.5%	14%	15%	13%	

Table 2.4 Causes of injury in admitted patients: all ages.

although becoming less common in more recent times. At the same time, assaults and sport have become more common and industrial accidents less common as causes of head injury. Age trends within these overall tendencies will be apparent from the following tables (2.5 and 2.6) which deal with adults and children separately.

Even allowing for earlier series being more selective and generally including more patients with more severe head injuries, these figures confirm the decline in road traffic accidents and industrial accidents and the increase in assaults in adults mentioned earlier. Adults injured in road traffic accidents were more often car occupants, while children were more often pedestrians (42, 45) as were the elderly (45). Cyclists were mostly aged 5-15 years and motorcyclists 15-30 years (45). The particularly low figure for road traffic accidents in Galbraith's series (16) and the correspondingly high figure for assaults reflects the urban source and the adult population, since, although increasing, the proportion is not so high in the SHIMS adult group (19%) and is as expected, lower still when all age groups are considered (13% in SHIMS). In children, road traffic accidents form a lower proportion which has

AUTHOR & STUDY YEAR	AGE RANGE & No. OF PATIENTS	RTA	HOME	WORK	SPORT	FALL	ASSAULT	OTHER
ROWBOTHAM ET AL 1945-51	13+ 1000	44%	8%	31%	3%	6%	3%	6%
KERR ET AL 1963-64	15+ 474 20% secondary referrals	48%	16%	14%	3%		13%	5%
GALBRAITH ET AL 1973-74	12+ 918	24%	10%	5%	3%	24%	26%	8%
SHIMS 1974	15+ 756			8%			19%	

Table 2.5 Causes of injury among adult admissions.

AUTHOR & STUDY YEAR	AGE RANGE & No OF PATIENTS	RTA	HOME	WORK	SPORT	FALL	ASSAULT	OTHER
ROWBOTHAM ET AL 1945-51	0-13 400	37%			3%	48%		12%
BURKINSHAW 1951-56	0-14 238	33%				60%		7%
PARTINGTON 1952-58	0-15 1172	38%				52%		9%
JAMISON & KAYE 1967-69	0-15 857	33%	17%	7% school				
CRAFT ET AL 1971-72	0-15 200 5% secondary referrals	33%	28%	13% school			7%	20%

Table 2.6 Causes of injury in admitted children

remained fairly constant over time. Home and school accidents have increased from 17% and 7% respectively (62) to 28% and 13% respectively (61) in the Newcastle area over a period of four years though the part played by selection of cases is not clear. Falls of all kinds were by far the commonest cause of head injury in children and were equally common in 0-4 year olds and 5-9 year olds (63). Burkinshaw (60) found falls from bicycles to be ten times as common in boys as girls (overall sex ratio was 3.25). Partington (63) found road traffic accidents were commonest in 5-9 year olds while in Jamison and Kaye's series (62) they were commoner in 5-8 year olds. Craft et al (61) agreed with Partington. Craft et al also found home accidents much commoner in children under three years of age.

Some authors have concentrated on particular causes of head injury, usually road traffic accidents or sport, although some have been even more specialised and considered injuries arising from horse riding. Barber (83) reported one hundred and fifty-four accidents associated with horses, following which patients were admitted to hospital. He calculated that horse-related accidents caused one hospital bed to be occupied almost constantly by a victim of such an accident. The study covered the years 1971 and 1972 when the general population served was 450,000. All ages were included and head injuries (undefined) accounted for 66%, the incidence of this type of injury being therefore 11.2/100,000. Peak age incidence in both sexes was at 10-20 years, and females greatly out-numbered males. One patient died, 22% of patients had other injuries themselves requiring admission, 14% had a fractured skull (25% compound) and there was one case of extradural haematoma and one of subdural haematoma. Post-traumatic epilepsy occurred in 3%.

Edixhoven et al (84) considered horse-related injuries occurring in Newmarket in the years 1973 to 1975 inclusive, a highly selected group because of the geographical location of the series with the increased likelihood of horse-related injuries occurring compared with the general population. Thus 89% of their six hundred and twenty-two patients (698 injuries) were employed in the horse

racine industry and the male/female ratio was 6.8, both reflecting the highly selected group. 14% were admitted. 19% of the injuries were to the brain, face and head and most of the brain injuries were due to falls, while face and head injuries were most often the result of kicks. None of the thirty-four knocked out due to falls had fractures or serious brain injury and of forty-eight facial injuries, nearly half had fractured facial bones.

Several authors have confined themselves to the epidemiology of road traffic accidents. Bull and Roberts (85) have shown that on the basis of sampling road traffic accident victims attending the Birmingham Accident Hospital in 1970, police figures underestimate the true number of accidents. They showed that all fatal cases were recognised but that a third of serious injuries and a third of slight injuries did not appear in police notifications. Low notification applied particularly to accidents involving and causing injury to the driver only and this applied especially to cyclists, of whom less than a quarter were notified to the police. This would suggest that in the epidemiology of road traffic accidents and, therefore, in part of head injuries, hospital statistics are more reliable for case finding than police figures. Dawson (86, 87) has detailed the economic results of road traffic accidents in great detail and will be referred to later.

d) Neurosurgical Units:

Again, road traffic accidents are the single commonest cause of admission. The paper of Moyes (64) includes children who had been in hospital because of head injury for more than three days and is not strictly speaking comparable to the other papers where all patients were secondary referrals from district general hospitals transferred for specialist care. Also the age range is narrow at 3-14 years and four patients were excluded because of incomplete information. This group of children is probably intermediate between children admitted to primary surgical wards and children transferred to neurosurgical units.

AUTHOR & STUDY YEAR	AGE RANGE & No OF PATIENTS	RTA HOME WORK SPORT FALLS ASSAULT			
SHIMS 1974	ALL AGES 424	38%	7%	7%	8%
JENNETT ET AL-1974+75	ALL AGES 785	37%			11%
JENNETT + MacMILLAN 1974 + 75	ALL AGES 785	37%		20%	
JEFFREYS + AZZAM 1975-76	ALL AGES 248	33%	26%	5%	9%
MOYES 1974+75	3-14 YEARS 87	61%			29%

Table 2.7 Causes of injury in patients admitted to neurosurgical units.

Road traffic accidents are the commonest single cause of head injury and this is particularly true in children, when the majority of patients are again pedestrians. The significantly lower proportion of children attending accident and emergency departments (44%), admitted to primary surgical wards (36%) and neurosurgical units (25%) has already been remarked on (17), as has the much higher proportion of boys among patients transferred to neurosurgical units (17). Road traffic accidents accounted for a larger proportion of patients transferred to neurosurgical units (38%) than of patients admitted to primary surgical wards (34%) and double the percentage of A&E attendances (18%) (17). Home accidents are next commonest followed by assaults. Assaults form a smaller percentage of neurosurgical patients than of admitted and A&E patients while for domestic accidents the reverse is true. Industrial accidents are about as common in neurosurgical units as in admissions to primary surgical wards, but about half as common as

in attenders at A&E.

Lindsay et al (88) retrospectively studied fifty-two head injuries due to sport and transferred to a neurosurgical unit over a five year period. These comprised 2.7% of the head injuries admitted to the unit during the same period. Golf was the commonest cause (27%) followed by horse riding (15%) and football (13%). The definition used by these workers for sport was narrower than that used in SHIMS (17), which explains why the latter indicated sport was responsible for 7% of head injuries transferred to neurosurgical units. The male/female ratio for the fifty-two patients was 3:1 overall, although for horse-riding it was 1:7, thus excluding horse-riding, the male/female ratio was 6.3:1. All golf injuries occurred in those under sixteen years of age and thirteen of these fourteen injuries were caused by a blow from a club, nearly all resulting in depressed fractures. Only one patient died (the result of a climbing accident) and over 80% made a good recovery. Half of those moderately disabled and half of those severely disabled were horse-riders. 19% of all patients developed early epilepsy and 23% had epilepsy at some time.

Road traffic accidents become proportionally more common as the patients are selected by severity of injury, constituting about 18% of A&E attendances of all ages, 34% of admissions of all ages and 38% of patients admitted to neurosurgical units. The study from General Practice indicated a high incidence of 39% although this was from a rural area (47). When particular age-groups are considered, pedestrians are much more often children or elderly people, irrespective of the source of the data. Adults are most often injured as vehicle occupants while the majority of motorcyclists injured come from a very narrow age-range (16-19 years). Cyclists are most often aged between 5-15 years. Falls form the commonest cause of head injury in children attending A&E departments and are of many different types, they are also relatively common in the elderly. Assaults affect mostly adults, are commoner in males and in urban areas and are on the increase. Industrial accidents are confined to the working population, being less common than they used

to be, and are predictably more common in men than in women.

The reports of the Hospital In-patient Enquiry divided head injury by place of occurrence into road accidents, home accidents and other. In 1964 the proportions of all head injuries in these groups were 45%, 17% and 38% respectively (66), by 1973 they had altered to 29%, 14% and 58% (74) and by 1976 25%, 14%, and 61% (68). Although responsible for 29% of all discharges and deaths in 1973, traffic accidents accounted for 36% of other and unqualified skull fractures (N803) and 73% of multiple fractures involving the skull or face with other bones (N804) as well as 34% of cases of concussion (N850) and 51% of cases of cerebral lacerations and contusions (N851) (74). Home accidents in the same year accounted for 14% of all head injury discharges and deaths but 18% of vault fractures (N800), 17% of other and unqualified skull fractures (N803) and only 2.5% of multiple fractures (N804) and 5.2% of facial fractures (N802) as well as 24% of cases with other and unspecified intracranial haemorrhage (N853) and 7.5% of cases of cerebral lacerations and contusions (N851) (74). One quarter of all head injury discharges and deaths in 1976 resulted from traffic accidents and the proportion of discharges and deaths due to multiple fractures (N804) which resulted from this cause had fallen to 60% (68). The proportions of all injuries included in rubrics N800-803 which resulted from traffic accidents were much the same in 1976 as in 1973 except for a 20% increase in the proportion of vault fractures resulting from road traffic accidents (68, 74). The proportion of cases of cerebral laceration and contusion (N851) which were the result of road accidents fell from 51.3% in 1973 to 45.5% in 1976 and of intracranial haemorrhage (N852) fell from 15.1% to 9.1% while the proportion of all cases of other intracranial bleeding (N853) due to road traffic accidents rose from 24% to 30% (68, 74). Home accidents accounted for proportionately fewer basal fractures, other and unqualified fractures and other intracranial haemorrhage in 1976 than in 1973 and proportionately more vault fractures and multiple fractures with other categories essentially unchanged (68, 74).

Traffic accidents accounted for 29% of all head injury discharges and deaths in 1973 and were more common as a cause in males (29%) than females (27%) whereas home accidents accounted for 14% of all cases, but 10% of male and 20% of female cases (74). In males road accidents were responsible for 21% of cases with fractures (N800-804) and 31% of cases without fractures (N850-854) and in females the proportions were 24% and 28% (74). Home accidents in males were responsible for 7.3% of cases included in rubrics N800-804 and 11% of cases included in rubrics N850-854 whereas in females the proportions were 15% and 21% respectively (74). In 1976 the proportion of male discharges and deaths due to home accidents was unaltered, however that due to traffic accidents had decreased to 26% (20% N800-804 and 28% N850-854) (68). In the same year the overall proportion of female discharges and deaths due to home accidents remained at 20% but the proportion for N800-804 increased to 17% whilst that for N850-854 remained at 21% (68). At the same time the proportion due to traffic accidents decreased to 23% (22% of N800-804 and 23% of N850-854) (68).

Among the sub-groups of head-injured patients the male/female ratio in 1976 was highest in those injured in road traffic accidents who developed intracranial bleeding other than subarachnoid, subdural or extradural haemorrhage (N853) when it was 5.0 (68). In cases with cerebral laceration and contusion (N851) the ratio was 3.2 and in cases with subarachnoid, subdural and extradural haemorrhage (N852) was 3.0. The overall ratio for traffic accidents was 2.11 and for home accidents 0.95. The highest ratio among patients injured at home was 4.0 (N804 + N851) and the lowest occurred in facial fractures (N802) when it was 0.82 (68).

For patients with diagnoses included in rubrics N850-854 and who were injured in road accidents the age-distribution has altered since 1973 (67, 68, 69, 70, 71, 74). In 1973 about one quarter of all such cases of either sex were children but by 1978 this proportion had fallen to about a fifth (70, 74). Between the ages of fifteen and thirty-four years the proportions in each age-group were higher in males. For example in 1973 51% of males

with intracranial injury without fracture, resulting from traffic accidents, were aged 15-34 years compared with 38% of females (74). In 1978 the proportions had risen to 56% and 43% respectively and were 27% and 19% in 15-19 year olds alone (70). Over the age of thirty-four years the proportions in 1973 were 24% of males and 36% of females, most of the female excess occurring in patients over forty-five years (74). In 1978 in the same age range the proportions were 24% and 34% respectively (70). Also in 1978 only 5.4% of males and 12% of females with such injuries were over sixty-four years (70).

Again considering only patients without fractures (N850-854) but this time due to home accidents, another age-distribution was evident. In 1973 41% of such cases in males were aged 0-4 years and 70% were children (0-14 years), a further 11% were aged 15-44 years, 7% were 45-64 years, 5% were aged 65-74 years and 7.1% were over seventy-four years old (74). In the same year among female patients 28% were aged 0-4 years and 42% were children, 16% were 15-44 year olds, 7% were 45-64 years, 8.5% were 65-74 years and 21% were over seventy-four years old (74). Between 1973 and 1978 the proportion of male and female cases occurring in 0-4 year olds remained fairly constant such that in 1978 the proportion of males in this age group was 40% and of females was 27%. (67, 68, 70, 74). However the proportion aged 5-14 years fell from 29% to 21% in males and remained constant (14%) in females (70, 74). The proportion aged 15-44 years increased from 11% to 16% in males and from 16% to 18% in females, whereas the proportions aged 45-64 years remained constant (7%) in males and fell from 12% to 7.9% in females (70, 74). There was a slight increase in the proportion of both males (5.0% to 5.8%) and females (8.5% to 9.1%) aged 65-74 years and a bigger increase in the proportion of males (7.1% to 9.4%) and females (21% to 24%) over seventy-four years old (70, 74).

2.1.8 TEMPORAL RELATIONSHIPS:

a) Time of Injury:

In accident and emergency departments, for all ages, most attendances with head injury occur between 17.00 and 24.00 hours (50% (17), 44% (52), 41% (18)) while for adult attenders only half arrived between 18.00 and 02.00 hours (50). Of those admitted, for all ages, more than half came to A&E after 18.00 hours, and 20% between 24.00 and 06.00 (25). Proportionately more of those admitted came outside office hours compared with those attending A&E departments (25, 52). For adult admissions 42% were admitted between 21.00 and 05.00 and 27% between 16.00 and 21.00 hours (16). In the case of childhood admissions, several distinct peaks are evident, the first and smallest occurring mid-morning, the second occurring in the early afternoon and the third and highest in the early evening (17.00 - 18.00) (63). Although true for each third of the group by age (0-4, 5-9, 10-13) this hourly distribution was most marked in 5-9 year olds and least in 10-13 year olds (63). Jamison and Kaye's (62) patients showed two peaks in the time distribution, a small peak in the early afternoon and a much larger one in the evening, maximal at 20.00 hours. Craft et al (61) however, identified three peaks, morning (11.00) afternoon (15.00) and evening (19.00). In their patients the largest peak occurred in the mid-afternoon, however their series was confined to the months of November, December, January and February when for reasons of light and weather, children are less likely to be injured in the evening than they are in the lighter warmer summer months.

b) Day of Injury:

In accident and emergency departments more than a third of patients attended on Fridays and Saturdays (17, 18). This bias towards the weekends was most evident when only adults were considered (45% attended an inner city A&E department between 17.00 hours on Friday and 09.00 hours on Monday (50)). 47% of adult admissions occurred on Fridays and Saturdays (16). Partington (63)



found no significant differences in the daily variation of childrens admissions, however more boys were admitted on Wednesdays and to a lesser extent Saturdays. This was true especially for boys aged 0-4 years while 5-9 year olds peaked on Wednesdays and Fridays and 10-13 year olds on Wednesdays. In Craft's series (61) peaks occurred on Thursdays and Saturdays.

c) Month of Injury:

Although SHIMS (17) suggests little difference in the monthly distribution of head injuries, this is probably only true when applied to adults, since for obvious reasons, children are more likely to be injured in the spring and summer. Partington (63) showed that for each of seven consecutive years, more childhood cases occurred in summer. This seasonal variation was most evident in those aged 5-9 years and 0-4 years and especially in boys. Oddly, the month of June showed a drop compared with May and July. This was due to a drop in boys rather than in girls and was particularly apparent in boys aged 0-4 and 5-9 years, although also evident in girls aged 5-9 years but not in girls aged 0-4 years and 10-13 years when contrarily there was a peak. This was confirmed by Jamison and Kaye (62) who found admissions in the summer (307) were almost three times as common as in the winter (117). As we have seen, children constitute a large proportion of any series of head injuries and this would emphasise a seasonal trend.

2.1.9 GEOGRAPHICAL VARIATION WITHIN BRITAIN:

Field (14) has shown that from 1968-1972 inclusive the standardised hospital admission index for head injury by hospital regions in England and Wales varied from one hundred and twenty-four in Oxford to eighty-five in Manchester, although most regions were between ninety and one hundred and ten. In the same way, Field detailed the Standardised Mortality Ratio (SMR) by region in England and Wales for the years 1968-1972 inclusive and found a range from eighty-three in the North East Metropolitan Region to one hundred and sixteen in Liverpool and that except for the six regions with

SMRs between ninety-six and one hundred and four the higher and lower SMRs were significantly different from the country as a whole at least at the 0.05 level. Broadly speaking SMRs were lower in the South of England than in the North.

In 1974 the overall incidence for head injury admission in Scotland (313/100,000) was 16% higher than in England (270/100,000) (19). In addition to these broad differences, urban and rural variations were apparent. For the whole of England and Wales the number of head-injured patients attending General Practitioners has been estimated at 140/100,000 (46) while for a more rural area it was 390/100,000 (47). The number of episodes of head injury seen in General Practice was 340/100,000 in rural areas and 220/100,000 in urban areas (46). Reasonably, one would expect industrialised northern towns to have proportionately more head injuries occurring at work than in the South. The results of Lewin (43) and Rowbotham et al (42) would support this view.

In 1963 23% of road traffic accidents involving personal injury occurred in rural areas of Great Britain, but accounted for 39% of all deaths and 35% of all serious injuries, while 77% of road traffic accidents occurred in urban areas and accounted for 76% of all slight injuries (86). Five years later the proportion of road traffic accidents involving personal injury occurring in rural areas was again 23% and these accidents were responsible for 44% of all deaths and 35% of all serious injuries, whereas accidents occurring in urban areas accounted for 77% of slight injuries (87). Deaths per accident in 1968 were 1.03 in urban areas and 1.16 in rural areas. Serious injuries per accident were 1.13 and 1.44 respectively, slight injuries per accident were 1.29 and 1.71 respectively (87). Personal injuries of any degree of severity per accident were 1.24 in urban areas and 1.59 in rural areas. Since many road traffic accident victims have head injuries, we would expect head injury due to road traffic accidents to be more common and more serious in rural areas. This aspect will be further detailed below.

For adult attendances at an inner city accident and emergency department, Swann et al (50) reported that road traffic accidents accounted for 12% of head injuries while for A&E attendances of all ages in Scotland, road traffic accidents accounted for 18% (17, 18). For assaults the difference is more evident since for the whole of Scotland, assault accounted for 22% of all adult A&E attendances (18) yet in inner Glasgow accounted for a third of attendances (50). The proportion of patients injured at work (10%) was the same in an inner city as in the whole of Scotland. Recent consumption of alcohol was noted in 46% of all attenders at an inner city A&E department (in 71% of those assaulted) (50) compared with 22% of adult Scottish A&E attenders with head injury (17). Strang et al (18) have shown significantly different rates of alcohol consumption between A&E attenders at city hospitals (26%), at hospitals within thirty miles of a city (20%) and at more distant hospitals (15%).

MacMillan et al (25) divided patients admitted to primary surgical wards in Scottish hospitals into three groups according to their distance from a city. By this means they were able to show differences in regard to some characteristics of head injury admissions. Thus road traffic accidents accounted for 45% of head injury admissions to hospitals more than thirty miles from a neurosurgical unit, but only 31% of admissions to city teaching hospitals. For assaults the figures were 21% for city teaching hospitals and 9% for hospitals more than thirty miles from a neurosurgical unit, while hospitals less than thirty miles from such a unit were intermediate (36% for RTAs and 11% for assaults). City teaching hospitals admitted only 19% of A&E attenders with head injury, more distant hospitals admitted 35% of A&E attenders. In keeping with the results for A&E attendances detailed above, recent alcohol consumption occurred in 47% of admissions to city teaching hospitals and in only 23% to more distant hospitals. Sport accounted for 9% of admissions to city hospitals, for 13% to hospitals less than thirty miles from a neurosurgical unit and for 18% to hospitals more than thirty miles from a neurosurgical unit. Evidence of brain damage was more common in city teaching hospitals (74%) than in

either hospitals less than thirty miles from a neurosurgical unit (59%) or hospitals more than thirty miles from a unit (65%). The proportions with a history of altered consciousness and skull fracture were very similar in all three types of hospital. A major extracranial injury occurred in more patients who were admitted to city hospitals (21%) than to hospitals more than thirty miles from a neurosurgical unit (17%), which is surprising, both in view of the higher proportion of road traffic accident victims admitted to the latter and also from Dawson's work detailing urban and rural differences for death, serious injury and slight injury following road traffic accidents. Patients tended to remain longer in peripheral hospitals than in city hospitals. Galbraith et al (16) reported on adult admissions and their findings support the low road traffic accident and high assault distribution for urban hospitals while the paper by Barr and Ralston (53) supports the high road traffic accident and low assault distribution of rural hospital admissions.

2.1.10 ADMISSION RATE:

Several years ago, Jennett (89) suggested that between a sixth and a fifth of A&E attenders with head injury were admitted. More recently MacMillan et al (25) reported that 19% of adult A&E attenders at a city teaching hospital were admitted, 22% of A&E attenders at hospitals less than thirty miles from a neurosurgical unit, 35% of A&E attenders at hospitals more than thirty miles from a neurosurgical unit and 22% of all children attending A&E departments at children's hospitals. On average, throughout Scotland 23% of A&E attenders with head injury were admitted (18). For an inner city A&E department the admission rate for all attenders (over 13 years) was 28% (50). In 1977 in Nottingham, only 13% of head injury attenders aged fifteen years or above were admitted (51).

Few studies disclose the proportion of head injury admissions which are admitted to neurosurgical units. For three Scottish neurosurgical units these proportions were 3% in Dundee, 4%

in Aberdeen and 5% in Glasgow (19). The same paper stated that in the catchment area of the Edinburgh neurosurgical unit, 35% of head injury admissions were admitted directly to the neurosurgical unit and went on to say that in England and Wales as a whole 5% of all head injury admissions are transferred to neurosurgical units. However, for Mersey Region this proportion was only 1.2% (56) and not 1.5% as quoted by Jennett (19). Furthermore the proportion in North East England was 25% (19). Earlier estimates suggested 3% of hospital admissions for head injury in Scotland, excluding Edinburgh, in 1974, were admitted to neurosurgical units while earlier still the proportion was 4% (17). MacMillan et al (25) reporting a retrospective study of head injury admissions to primary surgical wards in Scottish hospitals, excluding the Lothians, in 1974, found only 1.4% of the surveyed population were referred to regional neurosurgical units. This figure is less than half that quoted for the same year for the neurosurgical units in Scotland excluding the Lothians (17) but almost identical to the figure from the Mersey Region (56). Jennett et al (29) amplified the results from the neurosurgical units in 1974, but included an additional three hundred and sixty-one patients from two of the three units (Aberdeen and Glasgow) admitted in 1975. This article does not explain the discrepancy between MacMillan's and SHIMS figures. Swann et al (50) found that 1.4% of all A&E attenders were transferred, which is equal to 5% of admitted patients. Fifteen years earlier, Barr and Ralston (53) reported that 2% of their five hundred and thirty-two patients were transferred to the neurosurgical unit. In Galbraith's series (16) a little under 3% were transferred to the neurosurgical unit and the period covered overlapped the earlier two-thirds of that covered by SHIMS (17) and MacMillan et al (25).

2.1.11 NEUROLOGICAL STATUS:

a) General Practice:

Perkin (47) reported that 28% of children and 53% of adults were concussed and the incidence of skull fracture and intracranial

damage paralleled the duration of concussion at all ages. Concussion was less common in patients with scalp lacerations than in patients with scalp bruising. Only 5.5% of all cases had skull fractures and intracranial damage, and half of these were children. Children had uncomplicated fractures more often than adults.

b) Accident and Emergency Departments:

Strang et al (18) discussing A&E attenders of all ages at all Scottish hospitals in 1974 considered indices of brain damage, defined as any alteration of consciousness since the injury or an observed inability to obey commands or talk sensibly when examined in the A&E department. In 80% there was no evidence of brain damage by these criteria, 15% had suffered altered consciousness but were fully recovered when seen in A&E, the remaining 5% had altered consciousness when seen in A&E. 12% of those with no evidence of brain damage were admitted and these accounted for 42% of all admissions. 66% of those with only a history of altered consciousness were admitted and accounted for 44% of all admissions, and 70% with altered consciousness on initial examination were admitted and accounted for 15% of all admissions. It is not clear why the 34% (of 15%) with only a history of altered consciousness, and the 30% (of 5%) with altered consciousness on initial examination were not admitted. 81% of admissions were fully conscious in A&E and had no fracture, but nearly a half had a history of altered consciousness. The proportion X-rayed and the proportion with skull fractures increased with increasing evidence of brain damage. Thus of those with no evidence 51% had skull X-rays and of those X-rayed, 1.3% had skull fractures, while for those with altered consciousness on initial examination 76% were X-rayed and of these, 15% had a skull fracture. In the North East of England in 1977, 15% of A&E attenders with mild head injury had an initial period of unconsciousness of less than sixteen minutes, the remainder had no such history (52). 9.5% had post-traumatic symptoms. All patients were talking and only 3.6% were not alert and orientated at the time of examination.

Since 1974 the Glasgow Coma Scale (GCS) (90) has become widely used in the U.K. (91) and the rest of the World. Most adult head injuries presenting at an inner city A&E department were fully conscious when first seen, 97% were talking and 90% scored 15 on the G.C.S (50). To differentiate patients, Swann et al (50) devised an ad hoc scale based on post-traumatic amnesia, altered consciousness, focal signs, post-traumatic convulsions, headaches and vomiting. Half of all attenders had at least one of these characteristics, one quarter had post-traumatic amnesia and in 28% of these it lasted less than five minutes, in 36% from five minutes up to an hour and in 24% more than one hour, while in the remaining 12% although noted as present, the duration of post-traumatic amnesia was not recorded. In four-fifths of those with post-traumatic amnesia lasting longer than one hour, alcohol may have contributed to the amnesia. Thirty-two patients with no evidence of brain damage by the criteria described above were admitted, nearly half had major injuries elsewhere, seven had skull fractures, four could not have a skull X-ray and five were social problems. The remaining patient was not classified. 16% of patients with no post-traumatic amnesia were admitted compared with 64% of those with amnesia of any duration. Of those admitted, 43% had no post-traumatic amnesia. One might have expected that all patients with post-traumatic amnesia would have been admitted for observation. Some of those with amnesia not admitted would presumably have sustained their injury more than perhaps twenty-four hours before attending, and this could explain why they were not admitted. Since reasons for not admitting patients with post-traumatic amnesia are not given and admission policy is not outlined reasons can only be speculative. Headache and/or vomiting occurred in only a third of cases overall, but in more than half of those with post-traumatic amnesia and in less than a third of those with skull fracture. This study implies that all head-injured patients attending A&E were assessed neurologically and scored by the G.C.S, as well as having a history taken. However, since this was a prospective study in which the normal A&E record card was replaced by a data collection form, falsely high recording and overly good histories and examinations may have resulted. This is

not to detract from the results themselves, which clearly provide valuable information regarding adult A&E patients.

c) Admissions:

Barr and Ralston (53) classified their patients, all of whom had a history of unconsciousness following injury, by their level of consciousness on admission. 51% were fully conscious on admission and none of these developed any complications or died. 35% were confused to stuporose and 3% of these died. 14% were comatose and 26% of these died.

Steadman and Graham (45) also classified their four hundred and eighty-four patients by their conscious level on admission. However, in 23% of the total this fact was not recorded in the notes. 56% were conscious, 12% drowsy and 9% unconscious. Of the total, 40% were unconscious at some time and in 85% of these the period was less than one hour (in 40% there was no record of duration of unconsciousness). At follow-up 78% of four hundred and fifteen cases had post-traumatic amnesia of some duration (less than one hour in 56% of this group).

Three groups of patients were identified by Rowbotham et al (42) according to their level of consciousness on admission. 75% were conscious to confused and 3% of these died, proportionately fewer children under thirteen years of age died (1.6%) than did adults (3.7%); 9% were semi-conscious and 28% died, proportionately more children died (33%) than did adults (23%). The remaining 16% were comatose and 62% died, proportionately more being adults (69%) than children (40%).

MacMillan et al (25) described three categories of severity of brain damage: 44% were fully recovered from an episode of unconsciousness, 20% had neurological signs and symptoms and the remaining 36% had neither. Furthermore, 84% were talking normally and 97% were obeying commands. On admission 16% were confused and not talking, 3% would not obey commands and 3% had pupillary

inequality or unreacting pupils. The presence of skull fracture was correlated with the severity of brain damage.

The four studies described above dealt with head injury admissions of all ages. Galbraith et al (16) described adult head injury admission only, and found that 77% were unconscious for less than thirty minutes and only 2.5% were unconscious for longer than twenty-four hours. On admission 86% had no symptoms or signs related to their head injury. An earlier adult study by Kerr et al (33) included 20% secondary referrals, and divided patients by their conscious level into five defined groups. 56% were fully conscious on admission and 1.1% of these died while of the 10% who were comatose 70% died. The percentage of brain damaged survivors also increased with severity of brain damage as evidenced by their conscious level on admission.

Two papers from the Birmingham Accident Hospital are rather more difficult to interpret and compare since important epidemiological information is omitted (54, 55). However, 38% of five thousand, one hundred and fifty-two 'minor' head injuries were admitted because they had been knocked out, 30% because of a depressed conscious level, 15% because of amnesia, 12% because of symptoms (vomiting in 10% and severe headache in 2%), 4% because of neurological signs and 1% because of fits (55). These minor head injury admissions accounted for 85% of all head injury admissions. The neurological status of the remaining nine hundred and fifty-one patients admitted during the same period is not given, some however had minor head injuries but were not included in the group because they had other significant bodily injuries. One hundred and sixteen patients required craniotomy during the six year study period.

Three-quarters of direct admissions to the Edinburgh head injury unit in 1979 were alert and orientated on admission (73). Focal neurological signs were the reason for admission in only 1%, while 3% had a depressed conscious level. In nearly four-fifths the reason for admission was that the patient had been knocked out and in another 1% because a skull fracture was present, although 11%

overall had a skull fracture. In the remaining 16% of patients a combination of reasons for admission existed, including the four already mentioned as well as others.

Considering now those series dealing exclusively with children, Burkinshaw (60) used three categories of concussion for grouping his patients. 36% had slight concussion by his definition, 57% moderate concussion and 7% severe concussion. Skull fractures were most common (50%) in those with severe concussion who were X-rayed (94%), and complications also related to severity of concussion. Only one patient died and he or she was in the group with severe concussion. In Jamison and Kaye's (62) series, 36% had a history of unconsciousness, 29% had impaired consciousness on admission and this was less common in children under eighteen months old (13%) than in the remainder (30-34%). Drowsiness (63%) and vomiting (55%) were the most common symptoms, 16% had other neurological signs which increased in incidence with age. No patient who was drowsy or responded to voice on admission died. Craft et al (61) reported that 31% of survivors (only two out of two hundred died, 5% were secondary referrals) had lost consciousness at some time and of these, 84% lost consciousness for less than ten minutes and 1.6% for more than six hours.

d) Neurosurgical Units:

Jennett et al (29) using the Glasgow Coma scale (90) defined their patients thus: 13% scored 3-5; 21% scored 6-9; 11% scored 10-11 and 56% 12 or more. 30% had never lost consciousness, similar numbers were not talking (41%) or obeying (43%); 44% had a deteriorating conscious level and 13% had non-reacting pupils. In Jeffreys and Azzam's series (56), 35% were conscious on admission to the neurosurgical unit, 27% were drowsy and 38% unconscious. The respective percentages for the patients before transfer were 37%, 28% and 35%. On arrival at the neurosurgical unit 58% had a neurological deficit, while on arrival at the District Hospital only 37% had a neurological deficit, indicating deterioration in the patients condition in at least one fifth of cases between the

district hospital and the neurosurgical unit. In fact twenty one patients (8.5% of transferred patients) were adjudged to be brain dead when they arrived at the neurosurgical unit. Gentleman and Jennett (92) identified hypoxia and hypotension as potent causes of deterioration during transfer to the regional neurosurgical unit. In two-thirds of patients with predisposing events for hypoxia, such an event occurred during the journey. A third of those fitting prior to arrival at the neurosurgical unit did so during the journey.

The foregoing discussion serves only to quantify what common sense dictates, in as much as patients with more severe head injury, as evidenced by their neurological status on admission, are more likely to have a skull fracture on skull X-ray, to develop complications and to die. In the case of children this morbidity and mortality is less than in adults. A large number of admitted patients, irrespective of age, have no symptoms or signs on admission and this applies even more so to A&E patients.

2.1.12 SKULL FRACTURES AND RADIOLOGY:

a) General Practice:

5.6% of the three hundred and ninety-three episodes of head injury described by Perkin (47) resulted in skull fracture, half of them were children and fractures were more often uncomplicated in children than in adults. 36% of children with skull fracture were not concussed. All fractures and brain damage in adults were associated with some loss of consciousness. The Second National Study of General Practice found the incidence of head injury included in ICD rubrics N800-N803 was 40/100,000 for all patients (50/100,000 in males and 20/100,000 in females). The highest male incidence was in 15-24 year olds (110/100,000) and the highest female incidence was in 0-4 year olds (50/100,000).

b) Accident and Emergency Departments:

SHIMS (17) reported only 50% of patients had a skull X-ray

at their first attendance, while a further 2% were asked to re-attend for X-ray. 3% of those X-rayed had a skull fracture. Strang et al (18) included those patients identified by SHIMS and added five hundred and twenty-three further patients so as to include all Scottish A&E attendances. 58% of the total were X-rayed and of these 2.7% had a skull fracture. This latter finding was most common in those patients with more severe brain damage. If those not X-rayed were assumed to have no skull fracture then the incidence of radiologically proven skull fracture for all A&E patients with head injury was 1.5%. 46% of patients with scalp wounds had skull films and only 1.6% of those X-rayed had a skull fracture or 0.7% of all patients with scalp wounds. Again assuming that those not X-rayed had no fracture then of those with a scalp wound, but no evidence of brain damage, only 0.3% had a skull fracture, compared with 3% of those with evidence of brain damage. In Newcastle, 62% of A&E attenders with mild head injury had skull X-ray and 1.4% had linear fractures, an overall incidence of 0.9%, if patients not having X-ray are assumed to have no fracture (52).

From an adult population of A&E attenders, Swann et al (50) determined that 65% had skull X-rays and that in 27% of those X-rayed the radiologist considered one or more views inadequate, although nearly all X-rays were considered satisfactory by the doctor in A&E. These latter findings were similar to those of an unpublished report by Jennett (93). They also concluded that alcohol was not responsible for the unsatisfactory nature of the skull films. Of those X-rayed, twenty-four had fractures (4.7%), the A&E staff missed three of these (12.5%) and two of the three were sent home (50). Conversely, A&E doctors diagnosed two skull fractures on films subsequently rejected as normal by radiologists. Overall, assuming that if a patient was not X-rayed there was no fracture present, the incidence of fracture was 3.1%, more than twice the proportion reported by Strang (18). 58% of patients with scalp wounds were X-rayed and 5% of them had a skull fracture, again higher in proportion (more than three times as high) than found by Strang. More than a quarter of those with a fracture had no evidence of brain damage by the authors definition although all had

scalp wounds. Of those not X-rayed a quarter had evidence of brain damage most often confined to headaches, vomiting or brief post-traumatic amnesia, although three out of sixty-one such patients had altered consciousness on initial examination!

c) Admissions:

Barr and Ralston (53) reported that 92% were X-rayed but did not state how many had skull fractures. Steadman and Graham (45) reported that 23% of those in whom the presence or absence of fracture was recorded (three quarters of total) had a fractured skull, which is higher than in other series. The presence of thirty-five secondary referrals does not account for all of this difference. 28% of the fractures were depressed and four-fifths of these were compound, most being secondary referrals. The information is not complete as regards skull fracture in Rowbotham's series (42) but at least 8.8% of adults had a skull fracture and half of these were compound vault fractures.

SHIMS (17) reported 7% of those X-rayed had a skull fracture. MacMillan et al (25) further described the same group of patients, of whom 90% had skull X-rays, varying from 97% at city teaching hospitals to 93% at other hospitals. Of those X-rayed and having skull fractures, the fractures were more than half as common again in children (10%) as in adults (6%). Fractures were nearly twice as common (13%) in those with evidence of brain damage (as defined by the authors) as in those with no such evidence (7%) and more than twice as common as in those with a history of altered consciousness who had recovered by the time of examination (5%). Fractures were more than three times as common in those with pupillary abnormality (21%) as in those without (6%) and nearly five times as common in those not obeying (28%) as in those obeying (6%). Length of stay was longer in those with fractures and within this group increased with increasing severity of brain damage.

In Galbraith's series (16) of adult head injury admissions, eighty-nine (9%) had fractures, of which five were depressed and

four of these latter were compound. As I have already said, Healy et al's (57) patients were all adults and the incidence of radiologically evident fracture was 5%. In a partially selected series from Edinburgh, 11% had a skull fracture (73). 85% of Burkinshaw's series (60) of children were X-rayed and 23% of those X-rayed had a skull fracture. Fracture was more common in those with more severe head injury, in those with complications (63% of those with fracture had no complications irrespective of the initial severity of the head injury) and in those with sequelae (59% of patients with fractures had sequelae, 45% with no fracture had sequelae). In Jamison and Kaye's series (62), 26% of children X-rayed had a fracture and in a fifth of them it was depressed. A further 3.2% were diagnosed clinically as having a fractured base of skull, though skull X-ray was negative. A later report from Newcastle revealed 18% of all children included in the series had a skull fracture and nearly a sixth of these were depressed fractures (61).

d) Neurosurgical Units:

In patients admitted to three of the four neurosurgical units in Scotland in 1974, 65% of those X-rayed had a skull fracture (17). A further report from the same three units but including additional patients admitted to two of the units during the following year revealed that 60% had a skull fracture and a third of the fractures were depressed (29).

Again the discussion above serves only to quantify what should be self-evident, that fractures are more common in patients with more severe head injuries by whatever means the severity is measured. Assuming that patients not X-rayed do not have a skull fracture, the overall incidence is 1.5% for all accident and emergency patients, about 7% for all admitted head injuries and 60% for head-injured patients transferred to neurosurgical units. Pro rata fractures are commoner in children (10%) than adults (6%), depressed fractures are also commoner in children and since such a fracture is a common reason for referral, commoner in patients

admitted to neurosurgical units than in those admitted to primary surgical wards.

National statistics reveal that between 1960 and 1978 the proportion of the total estimated discharges and deaths which were due to skull fractures (N800, 801, 803, 804) fell from 14.3% to 5.6% (66, 67, 68, 69, 70, 71, 74). During the same period the total number with such fractures fell by a third from 12,090 to 8,070 (66, 67, 68, 69, 70, 71, 74). In 1960 the ratio of vault fractures to basal fractures was 0.98 (66) and in 1978 was 1.29 (70). The number of vault fractures in 1960 was 2,540 (66) and rose to 3,400 in 1978 (70) having been over 4,000 in 1971 and 1972 (67). In contrast the number of basal fractures in 1960 was 2,580 (66) and increased to only 2,630 in 1978 (70), but was over 3,000 in 1973 (67). Multiple fractures of the skull or face with other bones increased from 2,580 in 1960 to 3,690 in 1965 (66) and then declined to only 520 in 1978 (70). In 1960 the total number of other and unqualified skull fractures was 4,410 (66) and declined by almost two-thirds to only 1,520 in 1978 (70).

2.1.13 TRAUMATIC INTRACRANIAL HAEMATOMA:

This topic will be discussed separately later, however for completeness the incidence as determined from the papers discussed in this section will be given now in Tables 2.8 A and B

a) General Practice:

Neither of the two studies discussed previously details the incidence of intracranial haematomas.

b) Accident and Emergency Departments:

For adult A&E attenders the incidence of post-traumatic intracranial haematoma was small, only 7.7/1000 attendances in one study (50). Strang et al (18) and Maitra (52) did not disclose what proportion of their patients developed this complication.

c) Admissions:

The incidence per thousand admissions of the various types of haematoma are shown in Tables 2.8 A and B. There is quite marked variation in rates due to different methods of selection. However most agree that subdural haematoma is about twice as common as extradural haematoma, while the incidence of extradural haematoma and intracerebral haematoma is similar.

d) Neurosurgical Units:

Tables 2.8 A and B also show the incidence rates for the studies from the neurosurgical units discussed so far. Results from both centres are similar and concur that subdural haematoma is twice as common as extradural haematoma. In the Scottish series the incidence of extradural and intracerebral haematoma is similar.

AUTHOR & STUDY YEAR	AGE RANGE AND No. OF PATIENTS	INCIDENCE/1000 ADMISSIONS				COMMENTS
		ALL	EDH	SDH	ICH	
BURKINSHAW 1951-56	0-13 YEARS 238	4.2				Total incidence 1 patient with subarachnoid haemorrhage
JAMISON AND KAYE 1967-69	0-14 YEARS 857	16	4.7	12		All cases of EDH survived without handicap half cases of SDH died
CRAFT ET AL 1971-72	0-14 YEARS 200		10	5		5% were secondary referrals
JENNETT ET AL 1974-75	ALL AGES 785	350	90	230	100	Some patients had more than 1 haematoma Neurosurgical patients
JEFFREYS AND AZZAM 1975-76	ALL AGES 248	140	300			Neurosurgical patients

Table 2.8(A) Approximate incidence of intracranial haematomas.

AUTHOR & STUDY YEAR	AGE RANGE AND No. OF PATIENTS	INCIDENCE/1000 ADMISSIONS ALL EDH SDH ICH	COMMENTS
ROWBOTHAM ET AL 1945-51	13 YEARS + 1000	33 69	Likely to include many secondary referrals
LEWIN 1948-53	AGE RANGE ? 1750	58 26 27 5.1	Age range not stated. Likely to be high because 16% secondary referrals
STEADMAN & GRAHAM 1958	ALL AGES 484	23 8.3 14 -	Overestimate because 7.2% secondary referrals
GALBRAITH 1973-74	12 YEARS + 918	7.6	Operated patients only
JENNETT ET AL 1974	ALL AGES 12460	12 3.0 7.9 3.3	Assumes all cases transferred to NSU. Some patients had more than 1 lesion
JEFFREYS & AZZAM 1975-76	ALL AGES 20273	1.7 3.7	Assumes all patients transferred to NSU
HEALY ET AL 1976-77	ADULTS 2000	9 2.5 6.5 -	
MENDELOW ET AL 1979	ALL AGES 1297	20 1.5 19 INTRADURAL	Few children therefore biased towards older patients and SDH

Table 2.8(B) Approximate incidence of intracranial haematomas.

The exact individual incidence of subdural, extradural and intracerebral haematomas cannot be determined from published national statistics. However the incidence of subarachnoid, subdural and extradural haemorrhage without mention of cerebral laceration or contusion (N852) and other and unspecified intracranial haemorrhage (N853) can be determined. In 1960 patients in the former group accounted for 540 cases in England and Wales, equivalent to 6.4/1000 discharges and deaths or 1.2/100,000

population (66). Thereafter numbers see-sawed a little although rose overall to 970 cases in 1978, equivalent to 6.7/1000 discharges and deaths or 2.0/100,000 population (70). Other types of intracranial haemorrhage (N853) accounted for 310 cases in 1960, equal to 3.7/1000 discharges and deaths or 0.7/100,000 population. Thereafter numbers rose in the sixties before declining in the seventies and reached 260 in 1978, having been 160 in 1977 and 510 in 1965 (66, 67, 68, 69, 70). The total number of cases in 1978 was equivalent to an incidence of 1.8/1000 discharges and deaths or 0.5/100,000 population. In 1978 therefore the overall incidence of these lesions (N852 + N853) was 8.5/1000 discharges and deaths or 2.5/100,000 population.

2.1.14 LENGTH OF STAY:

This has often been used as an indirect measure of severity. 25% of Barr and Ralston's (53) patients were admitted for up to forty-eight hours and 30% for more than seven days. At about the same time in Cardiff 54% stayed less than forty-eight hours and 4% longer than a week (45). Field (14) presented the cumulative percentage discharge rate for head injuries in England and Wales in 1972 and showed that for skull and facial bone fractures (N800-N804) 22% were discharged in less than two days and 44% in less than three days, while for those with intracranial injury without skull fracture (N850-N854) 54% were discharged in less than two days and 73% in less than three days. In 1974 in Scotland, excluding the Lothians, two thirds were discharged within two days and only 14% stayed more than one week (17). MacMillan et al (25) gave a more detailed account of these latter figures and found the median length of stay was 1.6 days. Patients with skull fracture stayed nearly three times as long (4.3 days) as those without (1.5 days). They also showed how extracranial injury prolonged stay irrespective of the severity of brain damage thus the median length of stay for patients with signs and symptoms related to their head injury but no extracranial injury was 1.3 days, while for the same group of head-injured patients with major extracranial injury the median length of stay was 6.8 days. If this last is not appreciated and

allowed for, assessment of severity of head injury merely in terms of length of stay will give a distorted picture. Patients also tended to stay longer if admitted to rural hospitals and shorter if admitted to childrens hospitals. Discussing adult admissions only, Rowbotham et al (42) found a mean duration of stay of 12.9 days, yet over twenty years later Galbraith (16) showed 85% of patients stayed up to forty-eight hours and only 5% more than a week.

Rowbotham's group of four hundred children had a mean duration of stay of 9.3 days. In the same city twenty years later eight hundred and fifty-seven head-injured children occupied 3727 bed days, a mean duration of stay of 4.3 days, although eighty were admitted for more than one week and twelve more than one month (62). Again in the same city, two years later, 75% were discharged within forty-eight hours and 9% were detained for more than a week, although in most cases it was other injuries which delayed discharge (61).

Buxton (54) identified six thousand, one hundred and three patients with head injury of all degrees of severity admitted to the Birmingham Accident Hospital in the six years ending in 1975. No definition of head injury was given, nor indication of admission criteria, age or sex breakdown. 70% were discharged within twenty-four hours. More than three-quarters of those detained for three to seven days were kept in because of other injuries. A sub-group of these six thousand, one hundred and three patients were described as minor head injuries (55), 83% were discharged within twenty-four hours and 92% within forty-eight hours.

Jennett (19) reported that patients with a major extracranial injury and only a minor head injury accounted for one third of occupied bed days but only 11% of head injury admissions. Also, patients without major extracranial injury, skull fracture or evidence of brain damage accounted for another third of occupied bed days and two thirds of admissions for head injury (19). Other authors found head injuries accounted for 5% of all surgical admissions occupying eight hundred and ten bed days per year (53).

More recently in an urban hospital head injury represented 27% of all adult, acute male surgical admissions (16). In the series from Edinburgh in 1979 although patients with concussion accounted for almost 90% of admissions they occupied less than half the total of bed days (73). The mean duration of stay for all fourteen hundred and forty-two patients, including a hundred and forty-five secondary referrals, was 3.7 days. For patients with concussion the mean duration of stay was 1.6 days, for patients with skull fracture 7.8 days, for patients with severe head injury 20.5 days and for patients with intracranial haematoma 25.4 days.

If the change in length of stay apparent over the last twenty years is a true reflection, then the severity of head injuries must have lessened. However Field (14) has shown that all the increase in admissions between 1963 and 1972 was due to an increase in patients admitted for one day or less. This fact alone would account for an apparent lessening of severity if length of stay was the criterion used. Field detailed length of stay longer than seven days and longer than two weeks in England and Wales from 1962 to 1972 (omitting 1965) and by using this as an indirect measure was able to show a decline in serious head injury from a peak in the mid-sixties. Thus in 1964, 31,481 patients with head injury were admitted for more than one week and by 1972 this figure had fallen to 22,429, a drop from 31% to 16% of the total number of admissions during a period in which the number of admissions rose by nearly 40%. Jennett (19) supported Fields view that severe head injury has declined both for the reasons Field himself gave and because of the falling numbers of head injury deaths.

Jeffreys (56) reported that 3% of patients were still in hospital three months after their injury and Jennett (29) reported a median duration of stay for three Scottish neurosurgical units of seven days, although the mean duration was thirteen days, mainly owing to patients in Aberdeen and Dundee staying for over a month.

National statistics for 1962-67 show that the mean duration of stay fell from a high level in children under one year of either

sex and was usually longer in boys than girls (66). During this period the mean duration of stay in all children fell from 5.5 days in 1962 to 4.7 days in 1967. In 1974 the mean duration of stay in all children who had head injury without skull fracture (AN143) was 2.2 days in boys and 2.5 days in girls (94). In the following year in the same group of children the mean duration of stay in boys was 2.4 days and in girls 2.8 days, but for children with fractures (N800-804) was 4.6 days and 5.0 days respectively (67). In 1976 the mean durations of stay were 2.7 and 2.0 days (N850-854) and 4.3 and 5.5 days (N800-804) respectively (68) and in 1977 were 2.2 days and 2.3 days in children with fractures (95). However in 1978 in this same group of children the mean duration of stay was 2.5 days in boys and 2.3 days in girls (96).

Generally the duration of stay lengthened as age increased irrespective of the diagnostic group to which patients belonged, although it was always longer in patients with fractures than in those without (69, 70, 71). In 1978 the mean duration of stay in children aged 0-4 years who had fractures was 4.9 days in boys and 3.5 days in girls (70). Thereafter in males the duration decreased to a minimum of 3.7 days in 25-34 year olds before rising to 30.3 days in men aged 65-74 years and falling to 10.7 days in men over seventy-four years old. In females the mean duration of stay increased from 3.5 days in 0-4 year olds to 6.0 days in 15-19 year olds and then fell before rising to 16.3 days in 65-74 year olds and 16.6 days in women over seventy-four years. For male patients with head injury without skull fracture the mean duration of stay in 1978 rose from 2.6 days in 0-4 year olds to 3.8 days in 25-34 year olds, briefly fell and then increased to 8.2 days in 65-74 year olds and 8.6 days in men over seventy-four years. In female patients with the same injury, mean duration of stay increased from 1.9 days in 0-4 year olds to 4.0 days in 20-24 year olds, fell to 2.4 days in 35-44 year olds and then rose to 5.6 days in 65-74 year olds and 12.3 days in women over seventy-four years old. The mean duration of stay for all males with intracranial injury without skull fracture was 3.6 days in 1973 (74), 3.5 days in 1976 (68) and 3.5 days in 1978 (70). For the same diagnostic group the mean duration

of stay for all female patients was 5.2 days in 1973 (74), 4.1 days in 1976 (68) and 4.2 days in 1978 (70). For male patients with fracture the mean duration of stay in 1978 was 5.5 days and for female patients was 6.5 days (70). In the same year in Scotland the mean duration of stay for all male head-injured patients was 4 days and was also 4 days for all female patients (72). Duration of stay lengthened with age and was longer in elderly women than in elderly men.

In 1975 the mean duration of stay in Scotland was 5 days for males and 6 days for females (75) and by 1976 was 5 days for both sexes (97). In 1977 it had fallen further to 3 days in males and 4 days in females (98) and since then has remained at 4 days in females but increased again to 4 days in males (20, 72).

As one would expect among patients with skull fractures the length of stay was longest in those patients with multiple fractures involving the skull or face with other bones (N804). In 1973 in England and Wales the mean duration of stay in this group of patients was 25.1 days (29.1 in males and 17.2 in females) (74) and shortened to 21.6 days in 1976 (21.7 in males and 21.5 in females) (68). The shortest mean duration of stay occurred in patients with fractures of the facial bones (N802), being 4.4 days (4.0 in males and 5.4 in females) in 1973 (74) and 4.5 days (3.9 in males and 6.2 in females) in 1976 (68). In Scotland in 1975 the mean duration of stay in patients with fractures of the facial bones was 5 days in both sexes (75) and the following year had fallen to 4 days in males and risen to 6 days in females (97). For the two succeeding years it fell to 3 days in males and 4 days in females (72, 98) and in 1979 remained at 3 days in males but had risen to 5 days in females (20). In England and Wales in 1973 patients with basal fractures had a longer mean duration of stay than patients with vault fractures, 12 days versus 9.4 days (74) but three years later the mean duration of stay was 9.2 days in both (68). In the following year the mean duration of stay of patients with vault fractures was 8.5 days (95) and fell further to 8.2 days in 1978 (96).

Results from the Hospital In-patient Enquiry for England and Wales show that among patients with intracranial injury without fracture, mean duration of stay is longest in patients with cerebral laceration and contusion (N851). In 1973 this was 30.7 days (26.4 in males and 36.8 in females) (74) and in 1976 had fallen to 20.5 days (25.3 in males and 5.8 in females) (68). The shortest mean duration of stay occurred in patients with concussion (N850). In 1973 this was 3.6 days (3.2 in males and 4.4 in females) (74) and shortened slightly to 3.3 days (3.2 in males and 3.7 in females) in 1976 (68). Cases with other and unspecified intracranial injury (N854) also had a short mean duration of stay falling from 3.9 days in 1973 to 3.6 days in 1976 (68, 74). Also in 1973 the mean duration of stay in patients with subarachnoid, subdural and extradural haemorrhage (N852) was 15 days (13.7 in males and 17.6 in females) almost double the mean duration of stay of patients with other and unspecified intracranial haemorrhage (N853) which was 8.6 days (8.5 in males and 8.7 in females) (74). However in 1976 the mean stay of patients included in rubrics N852 was 12.1 days (10.6 in males and 14.5 in females) and of patients included in rubrics N853 was 12.4 days (11.8 in males and 13.1 in females) (68).

Irrespective of all other considerations the mean duration of stay of all head-injured patients without skull fracture was longest in patients injured in road traffic accidents, intermediate in patients injured at home and shortest in patients injured otherwise (67, 74, 94, 95, 96, 99). In 1978 the mean durations of stay in each of these categories in patients without skull fracture were 5.3, 5.1 and 2.8 days respectively (96). However, if the sexes are separated, the above relationship still holds in males but not always in females (67, 70, 74). For example in 1973 the mean duration of stay in females injured at home was 6.2 days and of females injured in road traffic accidents was 5.9 days (74). Generally for these two causes the difference in mean duration of stay was much narrower in females than in males (67, 70, 74). Furthermore the mean duration of stay for other causes is much shorter in males than in females (67, 70, 74).

Among elderly patients of both sexes, mean duration of stay is longer in patients with other conditions than in patients without other conditions (70, 74). For example in 1978 the mean duration of stay in males over sixty-four years with intracranial injury without skull fracture (AN143) was 9.9 days when another condition was present and 6.9 days when no other condition was present and in women the figures were 13.0 and 6.4 days respectively (70).

The median duration of stay is generally shorter than the mean duration of stay, often being about half the latter. In England and Wales in 1975 and 1976 the median durations of stay were 3.1 and 3.0 days respectively for patients with skull fracture and 1.8 days for patients without skull fracture (67, 68). In 1977 median duration of stay was between 2 and 3 days for patients with skull fracture and between 1 and 2 days for patients without skull fractures (69). In the same year 3.2% of all patients with fractures stayed longer than one month, 7.4% longer than two weeks and 16% longer than one week, whereas for patients without fracture the proportions were 2.0%, 4.0%, and 8.2%. (69). In 1978 the median duration of stay was 2.9 days for patients with fractures and 1.8 days for patients without fracture. (70).

The number of beds used per million population by all head injuries in England and Wales was 37 in 1960 and rose to 43 in 1967 (66). In 1978 the average number of beds used daily by head-injured patients with skull fracture was 251 in males and 117 in females and by patients without skull fracture was 738 in males and 496 in females (70). In both sexes bed use peaked in young patients then fell and rose again in the elderly (70). The average number of beds used daily by all head-injured patients was 1% of the total for England and Wales, 1.5% of all male and 0.5% of all female beds used (70). In Scotland in 1975 head injuries required the daily use of 7 beds per 100,000 males and 3 beds per 100,000 females (75). In the following year the figures were the same but fell to 5/100,000 in males and 2/100,000 in females in 1977 (97, 98). In the ensuing two years, figures rose again in males to 6 in 1978 (72) and 7 in 1979 (20) and in females were 3/100,000 in both these years (20, 72).

2.1.15 EXTRACRANIAL INJURY:

This aspect has been touched on in the preceeding section because of its impact on length of stay. In Rowbotham's series (42), 19% of patients of all ages had associated injuries and these were less common in children (9.5%) than in adults (22%). Of these associated injuries, limb injuries were commonest in both adults and children and were of equal incidence in both (52% in adults and 53% in children), facio-maxillary injuries were next commonest though slightly more common in children (37%) than in adults (35%). Thoracic injuries came next in frequency (adults 8.6% and children 7.9%). No children had spinal or abdominal injuries, which occurred in 5% and 1.4% of adults respectively. In Kilmarnock, 23% had associated minor injuries (contusions or abrasions) of the trunk and limbs and 10% had more serious injuries (lacerations or fractures) (53). Neither Steadman and Graham (45) nor Field (14) considered this aspect of head injury.

As we have seen in the previous section, 11% of minor head injuries admitted in 1974 had major extracranial injuries and these accounted for one third of occupied bed days (19). More detailed consideration of this aspect of head injury was given by MacMillan et al (25). They found that 39% of admissions had one or more extracranial injuries of which 59% were minor (soft tissue injury only or upper limb fractures). Therefore 16% of all admissions had major extracranial injuries and in 5% of all head injury admissions there was a major extracranial injury associated with a more than minor head injury. No major differences existed in the incidence of major and minor extracranial injuries between head injuries of different degrees of severity. Road traffic accidents were more often associated with major extracranial injury. Overall 20% of adult head-injured patients and 10% of children had cervical spine X-rays and a fracture or dislocation was revealed in five adults. If we assume those not X-rayed had no fracture, then the incidence of cervical spine fracture or dislocation in adult admissions was 6.6/1000 admitted. Surprisingly, in view of the fact that road traffic accidents are more common in rural series of head injuries

(53) and rural road traffic accidents are more often associated with death and serious injury (86, 87), MacMillan et al (25) found major extracranial injury to be more common in head-injured patients admitted to city teaching hospitals (21%) than to hospitals more than thirty miles from a neurosurgical unit (17%). Children's hospitals had fewest road traffic accident patients and fewest with major extracranial injuries (4%).

In the Birmingham Accident Hospital, 76% of patients who stayed between three and seven days (4% of the total of head injury admissions) did so because of extracranial injuries and of those who were detained for more than one week, 40% stayed because of injuries other than to their head (54). In an adult series from a city hospital, most associated injuries were trivial, only 6% had major extracranial injuries and only 1% multiple major injuries (16). Nearly one in seven direct head injury admissions to the Edinburgh neurosurgical unit in 1979 had multiple injuries (73). The studies of children admitted with head injury, which have been referred to in the preceding sections, did not consider associated injuries.

For Scottish patients admitted to three neurosurgical units, 18% overall had a major extracranial injury with a range from 15% in Glasgow to 31% in Dundee (29). These differences were in part the result of the higher proportion of head injuries due to road traffic accidents in Dundee (41%), compared with Glasgow (34%) and also the higher proportion transferred in Glasgow after twenty-four hours had elapsed, when many would already have died (29).

2.1.16 MORTALITY:

In regard to road traffic accidents, Ruffell Smith (100), and later Sevitt (101), studied the relationship between injury and time to death. The former found nearly 50% of deaths occurred in the first five minutes, 10% in the next ten minutes and 8% in the following ten minutes. Two-thirds occurred in the first twenty-five minutes, a time during which the majority are unlikely to arrive at

hospital. This study was based on a review of all post-mortem reports for accident victims dying in December 1966 (219 cases) and December 1967 (155 cases). All patients were adults. The author interpreted the reports of different pathologists to determine the injury most likely to have caused death, in some cases several fatal injuries occurred in the same patient, while in others the post-mortems were inadequate for the purpose of identifying a specific fatal injury. 18% had multiple fatal injuries, some of which must have included injury to the head and in 4% insufficient information was available. In those with an identifiable single fatal injury (289), one hundred and twenty-three (43%) died as a result of injuries to the head and neck, one hundred and twenty-seven (44%) as a result of chest injuries, twenty (6.9%) from abdominal injuries, seventeen (5.9%) from inhalation asphyxia and two (0.7%) from limb haemorrhage. For the whole series 33% died from head and neck injuries (29% and 4.3% respectively). No significant relationship was found between specific injuries and type of road user.

Sevitt (101) analysed all road fatalities occurring in Birmingham in 1969 and 1970. He identified two hundred and fifty-four deaths in a population of 1.084 million, the mortality rate therefore being 11.7/100,000. In 94% the elapsed time between the accident and death could be accurately determined, the remaining 6% were certified dead on arrival at hospital and were all considered to have died within half an hour of their accident. Some children who died may not have had post-mortems although this is not clearly stated. The male/female ratio was 1.7, 16% of patients were under fifteen years of age and 37% were over sixty years. Overall 63% were pedestrians and most of them were over sixty years of age (50%) or under fifteen years (22%). 23% were vehicle occupants (85% aged 15-60); 9.8% were motorcyclists (88% aged 15-40) and 3.9% were cyclists (50% under 15 years). 36% of all cases died within half an hour, 44% within one hour, 68% during the first twenty-four hours and only 6.7% longer than four weeks after their accident. 64% were alive on arrival at hospital. The higher proportion of vehicle occupants dying within one hour (54%) compared with pedestrians

(40%) almost reached statistical significance. 58% of deaths were due to brain injury varying from 42% for vehicle occupants to 100% for cyclists and the difference between vehicle occupants and pedestrians (61%) was significant. Motorcyclists had most fatal injuries with 1.5 per patient and cyclists least with 1.2 per patient. 42% of patients dying from brain damage did so in the first hour and 69% in the first day. Of vehicle drivers, 50% had consumed alcohol and in nearly three-quarters of these the level was more than 80mg%.

Whittington (102) discussed fifty-five motorcyclists (including some secondary referrals) who died in a three year period. All forty-six drivers were male and of the pillion-passengers, six were female and three male (male/female ratio 8.2). 47% were aged 16-20 years and 20% were seventeen years old. Most accidents happened at night and on Fridays in August and September (five times the winter rate). 35% of drivers had an alcohol level greater than 80mg%. 56% of fatal injuries involved the head and neck. There were 1.5 fatal injuries per patient. In twelve cases a crash helmet became detached, although half of these died other than of head injuries. Three helmets shattered on impact and all three patients received fatal head injuries. In two cases impairment of vision due to the helmet was thought to have occurred and in one instance no helmet was worn at all.

Motorcycle fatalities were also the subject of a paper by Harrop and Wilson (103). All motorcycle deaths occurring in a period of four years and eight months in a circumscribed area were studied. For comparison all non-fatal motorcycle accidents known to the police, causing personal injury and occurring in the latter eight months of the study period were collected. Seventeen deaths occurred in fifteen accidents, fifteen of the victims were male (male/female ratio 7.5) and only one patient was over twenty-one years of age. The mortality rate was 3.4/100,000 per year and eleven of the seventeen were dead on arrival at hospital. Eleven of the fifteen accidents occurred because of driver error and alcohol was a factor in three accidents among whom two drivers and one

million-passenger had a blood alcohol level of more than 80mg%. During the first four years of the study, accidents were twice as common in the summer as in the winter. More than half the motorcycle riders held only a provisional licence compared with half in the comparison group. The primary causes of death were head injury (29%) (four-fifths of patients wore crash helmets although three-quarters lost them in the crash), Atlanto-occipital disruption (29%), haemorrhage (35%) and fat embolism (6%). Many of the Injury Severity Scores quoted in this study were incorrect since the Abbreviated Injury Scale codes ascribed to several injuries were erroneous e.g., cerebral contusion was scored AIS=4 when in fact it should be AIS=3 (104).

A recent leading article in the British Medical Journal emphasised the high mortality associated with riding a motorcycle, and noted the increase in the number of casualties in the first nine months of 1976 (105). Three hundred and thirty-two people died from accidents involving powered two-wheelers in the third quarter of 1976, and during the same period there were four thousand, four hundred and sixty-eight serious injuries from the use of motorcycles. The overall daily total for all types of road accident was eighteen fatal and two hundred and thirty serious injuries. Motorcyclists accounted for 17% of fatalities and 22% of serious injuries each day. 63% of those involved in motorcycle accidents were aged 16-19 years. 34% of moderate injuries included injury to the head, while for fatal injuries this was 64%.

Field (14) reported that in 1972 41.9% of head injury deaths occurred in in-patients, 21.5% in accident and emergency departments, 5.8% at home, 0.9% in psychiatric and other hospitals and 29.9% in other places, other places probably being at the scene of an accident or in transit to hospital. Taken in conjunction with the review by Sevitt (101) detailed earlier, and the report by Jeffreys and Azzam (56), as well as Field's work, Jennett's (21) estimate that 40% of head injury deaths occur before a patient reaches hospital, 20% occur in accident and emergency departments before admission to wards, and 40% in in-patients is broadly

speaking reasonable. Jennett and Carlin (21) reported that of one hundred and twenty-two patients dying from head injury before admission to hospital, almost half were the results of a road traffic accident, 13% were due to falls and 6% due to railway accidents. Most had overwhelming injuries with brain-stem laceration, brain disruption, severe basal fracture, cervical fracture or dislocation.

This lengthy discussion of mortality occurring before patients reach hospital, and death due to road traffic accidents is justified by the proportion of all deaths involved. An additional reason being that papers referring to hospital cases do not usually include those patients who die before reaching hospital or those who die in accident and emergency departments.

a) General Practice:

Perkin (47) reported three deaths which occurred among three hundred and ninety-three head injury episodes, a mortality of 0.8%.

b) Accident and Emergency Departments:

SHIMS (17) reported a mortality of 0.1% of all A&E attenders with head injury at Scottish hospitals excluding the Lothians. Strang (18) reported on three thousand five hundred and fifty-eight patients attending the A&E departments of forty Scottish hospitals following head injury but did not determine mortality. The figure of 0.1% seems very low, representing only three deaths, probably because patients brought in dead (BID) and deaths after admission were not included. Swann et al (50) studied an adult population of A&E attenders with head injury and their mortality rate was 0.4%. They did not include BID's either.

c) Admissions:

15% of Rowbotham's (42) fourteen hundred patients died.

69% (121 patients) of adult patients admitted in coma died and in two-thirds of these all combinations of cerebral contusion and laceration, surface and intracerebral haemorrhage existed and the macroscopic appearances were thought sufficient to explain death. None died of uncomplicated concussion. Of those admitted in semi-coma, 27% died (27 patients), twenty of them had macroscopic evidence of brain injury and in half this was considered sufficient to cause death. In the remaining half, extracranial injuries were considered to have substantially contributed to death. Finally, in the seven remaining patients, who had no extracranial injuries, the authors felt that better surgical management might have saved life, especially when there was a large unilateral acute subdural haematoma. In those admitted in a state of confusion or full consciousness, 3.7% (27 patients) died. In three cases the head injury was mild and death resulted from severe extracranial injuries. Three more cases had an extradural haematoma associated with a subdural haematoma, cerebral laceration or intracerebral haematoma. Two cases were uncomplicated extradural haematomas. The remaining nineteen deaths occurred in patients with severe brain injuries not associated with extradural haematoma. In five of these sepsis was an important cause, four had non-traumatic intracranial haematoma, six died from cerebral laceration with either subdural haematoma or subarachnoid haemorrhage, three died following surgical treatment of severe compound frontal injuries and one died from cerebral thrombosis.

Death was more common in adults (18%) than in children (8.5%). The male/female ratio for the whole series was 3.5, and for those dying it was 5.3. In children 59% of deaths were the result of road traffic accidents and of these 85% were pedestrians. In adults 50% of deaths were due to road traffic accidents and of these 38% were pedestrians and 29% motorcyclists. Mortality steadily increased in each decade of life from 8.4% in 0-10 year olds reaching 38% in patients aged 61-70 years and in those aged more than 70 years it fell again so that in 71-80 year olds it was 33% of forty-nine patients and in those aged 81-90 it was 27% of eleven patients.

A report by Lewin (43) described seventeen hundred and fifty patients of whom 16% were secondary referrals, nevertheless mortality for the whole series was only 7.3% while for one thousand consecutive direct admissions it was 7.1%. This report was in part contemporaneous with that of Rowbotham, but the mortality was less than half that of Rowbotham, this despite including nearly twice as many road traffic accidents. Lewin does not give the age or sex distribution of his patients but possibly more young patients or more patients with minor injuries were included in his series which would tend to lower the mortality, or else Rowbotham included more severe head injuries, either as direct admissions or as an undisclosed number of secondary referrals, or more older people. Whatever the reason for the marked difference in mortality, it cannot be resolved by consideration of the information contained in the two reports, except that the incidence of acute subdural haematoma in Rowbotham's patients is three times that in Lewin's series, although the incidence of extradural haematoma is more or less the same in both. Generally speaking acute subdural haematoma is associated with more severe brain injury than is extradural haematoma.

In Ayrshire in the late nineteen fifties, the mortality in a series of five hundred and thirty-two patients of all ages admitted to a district hospital was 4.7% (53). 64% died within twenty-four hours and associated injuries contributed to death in about 31% of these. 96% of the deaths were the result of road traffic accidents. At about the same time in South Wales a study of four hundred and eighty-four head injury admissions of all ages was reported and despite 7% being secondary referrals, the mortality was 1.9% (45). 23% or less had a skull fracture but the incidence of subdural haematoma was about a fifth of Rowbotham's and more than half that of Lewin, while the incidence of extradural haematoma was a quarter that of Rowbotham and a third that of Lewin.

In England and Wales in 1972, five thousand, one hundred and seventy-five deaths from head injury occurred (14), 40% of these deaths occurred after admission and 20% died in accident and

emergency departments. The case fatality rate for admitted patients was 1.46% if patients dying at the scene of an accident, in transit or in A&E departments are excluded. This is similar to the figure found by Steadman (45) but less than that found by Barr (53). If A&E deaths were included, the hospital case-fatality rate was 2.2%. For all deaths the male/female ratio was 2.1, 32% of male deaths occurred in the 15-29 year age group, while for females 17% were aged 15-29 years. After peaking at 15-19 years in both sexes, a lesser peak occurred in men aged 60-74 years and in women aged 70-79 years. 54% of male deaths, 39% of female deaths and 49% of all deaths occurred in the under forty age group. The male excess of deaths was least marked at the extremes of life, but between ages 15-29 years was four times as high as in females. When age-specific mortality rates were considered the male/female ratio was 9:1 in 15-19 year olds. From age sixty-five in both sexes the ratio increased dramatically to reach its highest levels, more than double the age-specific rate for 15-19 year old males.

68% of the five thousand one hundred and seventy-five deaths in 1972 were the result of road traffic accidents, with a male/female ratio of 2.16. Falls accounted for 21% of deaths with relatively more women (male/female ratio 1.6), suicides accounted for 3.3% with a male/female ratio of 6.4, industrial accidents for 2.7% (male/female ratio 7.6), assaults 2.3% (male/female ratio 1.2) and other causes accounted for 3.2% of deaths. Road traffic accidents caused 85% of head injury deaths in 15-24 year olds. Most pedestrians killed were under fifteen years of age or over sixty-four years, most cyclists were 5-14 years old and nearly all motorcyclists who died were in the 15-24 year age group as were most car occupants who died. These age associations within road-users killed are very similar to those found when the subgroups of road traffic accidents leading to admission are classified by age. Falls tend to be more common in the older age groups and to a lesser extent in those under five years old when they accounted for 20% of deaths. They also accounted for 25% of female and 19% of male deaths.

Field also presented the standardised mortality ratios for males in the working age-group and according to social class for 1961. Social classes I and II were under-represented and social class V heavily over-represented, the standardised mortality ratio in social class V being more than three times that for social class I and about three times that in social class II. He also showed regional differences in standardised mortality ratios for head injury in England and Wales between 1968 and 1972. Lower standardised mortality ratios were found generally in the South of England than in the North. For those with a ratio more than 105 and less than 93, the differences were significant at at least the 0.05 level. Oxford, however, was anomalous since although having a well below average mortality rate from all causes, the standardised mortality ratio was significantly above average for head injury ($p=0.01$). Mortality from road traffic accidents is higher in rural than urban areas, a fact which may help to explain this anomaly. The standardised hospital admission index for head injury in England and Wales in the period 1968 to 1972 was generally lower in the North of England.

Annual head injury deaths in England and Wales have remained nearly constant since 1950, peaking in 1966 and then slowly declining to less than the total for 1950 by 1972 (14). Peaks and troughs in the annual totals mirror peaks and troughs in deaths due to road traffic accidents, while head injury deaths from other causes have steadily declined from two thousand five hundred (45%) in 1950 to about eighteen hundred (35%) in 1972 (14). The effect of the 1967 Road Safety Act on head injury deaths, especially those associated with alcohol, was dramatic in the year following its introduction, but the effect had almost disappeared by 1971 (14). The proportion of road traffic accident deaths from head injury in 1951 was 72% and by 1972 was 49% (14). The male/female ratio for deaths decreased from 3.45 in 1952, to 2.1 in 1972 (14) and during this time the male standardised mortality ratios have decreased, especially since 1966, while female SMR's have remained constant, but with a downward trend (14). Most of the male decline occurred in the 25-44 year old group but in 15-24 year old females the

standardised mortality ratio has increased (14).

Between the ages of fifteen and twenty years, a third of all male deaths and more than a fifth of all female deaths occur as the result of head injury (14). Between five and thirty years nearly one in five of all deaths were due to head injury. In the introductory chapter we saw how presenting causes of death according to the number of years of lost life gives a more realistic picture of their impact, more so if years of lost working life are determined (1, 2). In England and Wales in 1972, head injury accounted for 1.7% of all male deaths, but 3.0% of years of life lost and 6.3% of years of working life lost (14). The economic costs of all head injury deaths in Britain have not as yet been determined. Again for England and Wales, Field detailed the hospital case fatality rate for head injury in 1972 based on Hospital In-patient Enquiry Statistics. For all head injuries the rate rose from 0.6% in 0-4 year olds to 1.3% in 25-44 year olds, 2.1% in 45-64 year olds, 4.7% in 65-74 year olds and 9.7% in patients over seventy-four years of age. For patients with fracture of the skull and facial bones (ICD N800-N804), the increase with age was even more dramatic. Among 0-4 year olds the rate was 1.2%, 2.2% among 25-44 year olds, 5.7% in 45-64 year olds, 15.2% in 65-74 year olds and 23.1% in patients over seventy-four years old. Less dramatic rates obtained in patients with intracranial injury without skull fracture (ICD N850-N854), thus 0.5% in 0-4 year olds, 1.0% in 25-44 year olds, 1.2% in 45-64 year olds, 2.7% in 65-74 year olds and 8% in patients over seventy-four years old.

In 1974 in Scotland, excluding the Lothians, the hospital case fatality rate was 1% (17). For the succeeding years, 1975 and 1976 in Mersey Region, it was 1.5% and a further two hundred and twenty-six people died at the scene of accidents, giving an overall mortality rate of 8.3/100,000 per year (56).

In an adult series Kerr et al (33) stated the overall mortality was 11% and deaths were commoner in females (16%) than in males (9.6%). Secondary referrals made up one fifth of the total

number of patients and mortality was 20% while for direct admissions it was 8%. 47% of all deaths occurred within twenty-four hours and 65% of deaths were due to road traffic accidents and of the latter 79% were pedestrians. They showed that the worse the level of consciousness on admission, the greater the chance of dying and these differences were significant. They went on to show that level of consciousness, age, and the presence or absence of surgical shock accounted for 96% of the predicted variance in mortality. Over the age of fifty the correlation of age with death was highly significant and independent of level of consciousness, shock, extracranial injuries and internal haemorrhage. Galbraith et al (16) also described an adult population and the mortality was 1.6% for head injury alone, 73% dying within the first week. A mortality of 3% occurred among the direct admissions to the Edinburgh neurosurgical unit in 1979 (73).

In childrens series one would expect mortality to be lower. In Burkinshaw's series (60) mortality was 0.4%, Partington's (63) was 0.3% and Jamison and Kaye (62) had a rather higher mortality at 1.6%. Of the latter 71% died within forty-eight hours and of these, 71% were the result of a road traffic accident. Of these road traffic deaths 90% were pedestrians. All those who died responded only to pain or had a worse neurological state on admission. In the same city two years later, Craft et al (61) reported a mortality of 1% (2 patients) and their series of two hundred included 5% as secondary referrals. One of the deaths was due to non-accidental injury and the other the result of multiple injuries sustained by a pedestrian.

d) Neurosurgical Units:

The mortality rate in three Scottish neurosurgical units during 1974 and 1975 was 15% (29) while in the North West of England in 1975 and 1976 it was 19% in the short term and 23% in the long term (56). In a retrospective study of serious head injuries in children, resulting in hospital admission longer than three days, the mortality was 15% (64). Road traffic accidents were responsible

for 85% of these deaths and more than three fifths of them were pedestrians.

National mortality statistics for England and Wales from 1964 to 1980 are depicted in Figure 2.2 and Table 2.9 (106, 107, 108, 109, 110, 111, 112) the slow downward trend already noted by Field for the period 1950 to 1972 has continued. The lowest number of deaths occurred in 1980 when they numbered four thousand three hundred and eighty-five, a 26% drop from the 1966 peak. A further peak occurred in 1978 and was observed in both broad groups of patients and in both sexes (Figure 2.2). The decline in incidence was less apparent in patients with head injury without skull fracture (N850-N854) than in patients with fracture of the skull and facial bones (N800-N804). The latter group accounted for 74% of all head injury deaths in 1980 (112). Deaths in patients without skull fracture actually rose slightly in the early 1970's while the overall number of deaths was decreasing. This rise was largely due to an increase in the number of female deaths whereas the slight rise in 1976 was due to an increase in male deaths. Although all head injury deaths fell by about one quarter during the period, the decrease in female deaths was only 12% compared with 31% in males. For patients included in rubrics N800-N804 the drop in female deaths between 1966 and 1980 was 18% and in males 31%, but for patients included in rubrics N850-N854 the number of female deaths actually increased by 3.7% while male deaths decreased by 30%.

Dividing head injury deaths into two broad groups as above, disguises subtle differences within each three digit code. For all patients with skull and facial fractures the biggest changes occurred in patients with diagnosis N800 and N804. Deaths in these two categories decreased by 61% and 54% respectively between 1964 and 1980, while deaths included in rubrics N802, N801 and N803 decreased by 34%, 33% and 9.5% (106, 112). Similarly, deaths included in rubrics N850, N851, N853 and N854 decreased by 59%, 41%, 28% and 19% respectively. However deaths due to post-traumatic intracranial haematoma (N852) actually increased by 29%. This latter rise occurred due to an increase in both male and female

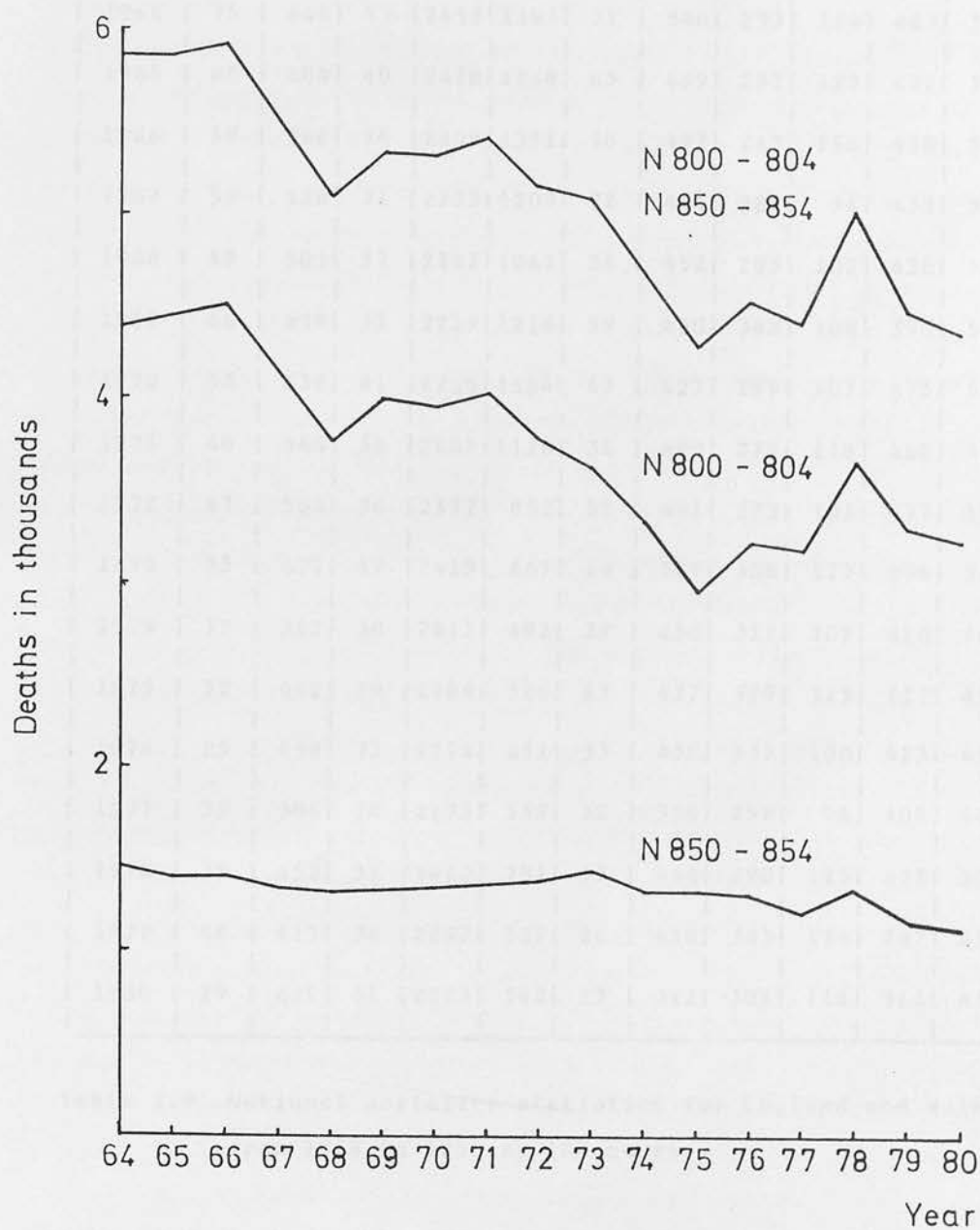


Figure 2.2 Annual Head Injury deaths: England and Wales
1964 - 1980

YEAR	ICD CODES										TOTALS
	N 800	N 801	N 802	N 803	N 804	N 850	N 851	N 852	N 853	N 854	
1964	75	644	47	2455	1183	71	546	233	164	443	5861
1965	68	604	40	2478	1268	65	489	293	129	422	5850
1966	58	596	54	2459	1351	58	497	247	156	458	5934
1967	56	528	31	2335	1208	72	464	288	94	438	5514
1968	59	503	37	2122	1061	56	452	285	102	428	5105
1969	46	499	32	2219	1216	59	430	348	104	390	5343
1970	53	436	41	2265	1184	47	427	299	107	473	5332
1971	48	446	34	2405	1118	31	490	278	118	460	5428
1972	47	504	36	2372	832	52	481	273	101	477	5175
1973	35	472	49	2419	667	44	529	308	123	456	5102
1974	32	382	38	2411	492	39	450	312	109	428	4693
1975	52	462	29	2104	320	43	437	329	115	417	4308
1976	25	450	33	2274	451	33	436	335	100	423	4560
1977	39	396	28	2175	559	32	396	298	94	405	4423
1978	39	452	37	2462	701	33	444	290	123	472	5053
1979	46	415	36	2297	527	26	418	343	111	287	4506
1980	29	429	31	2223	542	29	322	301	118	361	4385

Table 2.9 National mortality statistics for England and Wales
from 1964 to 1980 by ICD codes.

deaths, but particularly the latter which rose by 43% compared to 17% in males. The rise in female deaths in patients with skull fracture mentioned earlier was due to an increase of 3.9% in deaths among women with other and unqualified skull fractures (N803). All other categories in women showed a decrease in the number of deaths (106, 107, 108, 109, 110, 111, 112).

The male/female ratio for all head injury deaths in 1966 was 2.7 (106) and by 1980 had fallen to 2.1 (112). This alteration in the ratio is consistent with the changes in the mortality already noted above. In 1968 when the overall ratio was 2.4, the ratio in 0-14 year olds with fracture of the skull (AN138) was 1.7, in 15-29 year olds was 4.8, in 30-64 year olds was 3.2 and in patients over sixty-four years was 1.1 (113). During the same year the highest ratio was 6 and occurred in 25-34 year olds. By 1980 in the same age groups the ratios were 2.4 (all ages), 2.1 (0-14 years), 3.9 (15-29 years), 3.1 (30-64 years) and 1.1 (65 years and over), and the highest ratio was 6.2 (40-44 years) (112). For intracranial injury without skull fracture (AN143) the overall male/female ratio in 1968 was 2 (113). In children the ratio was 1.6, in patients aged 15-29 years was 4.1, in 30-64 year olds was 3.4 and in patients over sixty-four years was 1. The highest ratio occurred in 35-39 year olds (4.9). During 1980 the following ratios were observed: 1.5 (all ages), 1.4 (0-14 years), 4 (15-29 years), 2.4 (30-64 years) and 0.7 (over 64 years) (112). The highest ratio occurred in 30-34 year olds when it was 6.3.

The mean age at death for males with skull fracture (AN138) in 1968 was thirty-nine years while the median age was 34.5 years (113). In females mean and median ages at death were 47.3 years and 55.2 years. By 1976 the mean and median ages at death in males had decreased to 37.8 and 30.9 years respectively, and in females had increased to fifty-one years and 57.7 years (113). In 1980 the median age at death in males with skull fracture (N800-N804) lay between thirty and thirty-four years and for females was between fifty-five and fifty-nine years (112). For intracranial injury without skull fracture (AN143) the mean and median ages at death in males in 1968 and 1976 were little different (113). However in females they had risen from 55.5 to 57.7 years and from 67.2 to 68.1 years respectively. In 1980 the median age at death in patients with intracranial injury without skull fracture (N850-N854) was between thirty-five and thirty-nine years in males and between sixty-five and sixty-nine years in females (112).

The proportion of deaths from all causes which result from head injury is falling in both sexes. Between 1968 and 1980 in England and Wales the proportion of all deaths which were due to head injury, fell by 16% in males and 11% in females (112, 113). In 1980 head injury (N800-N804 and N850-N854) accounted for 1.02% of all male deaths but 30% of deaths in 15-19 year olds (112). In the same year head injuries accounted for 0.49% of female deaths from all causes and 20% of deaths in 15-19 year olds. Figure 2.3 shows the proportions of deaths from all causes in each age group which were the result of head injury in 1980.

In accordance with the preceding paragraphs the overall mortality rate due to head injury in England and Wales has also decreased. In 1968 this was 10.7/100,000 (15.3/100,000 in males and 6.3/100,000 in females) (113). Twelve years later the overall rate was 8.9/100,000 (12.4/100,000 in males and 5.6/100,000 in females) (112, 114). Age-specific mortality rates are shown in figure 2.4 for both sexes (112, 114). Among males the highest rate occurred in 15-19 year olds and was 258/100,000. Thereafter the rate declined before rising again in older people and reached its highest level of 532/100,000 in men over eighty-four years old. A similar relationship occurred in females where the highest rate in young women occurred in 15-19 year olds (69/100,000) and subsequently declined before rising to its highest levels in women over eighty-four years old (335/100,000). In all age groups the rate in males exceeded that in females. Although the male/female ratio for deaths in patients over eighty-four years was 0.5, the ratio of mortality rates in the same age group was 1.6.

As well as being responsible for a smaller proportion of deaths from all causes, head injuries accounted for fewer accidental deaths in 1980 than in 1964. Thus in 1964 head injuries accounted for 23.9% of all accidental deaths (E800-E999) in England and Wales (106). In 1980 the proportion had fallen to 21.6% (112). However between 1964 and 1980 in males, the proportion of all accidental deaths due to head injury decreased from 29.8% to 25.3%, whereas the proportion in females increased from 15.6% to 16.6% (106, 112).

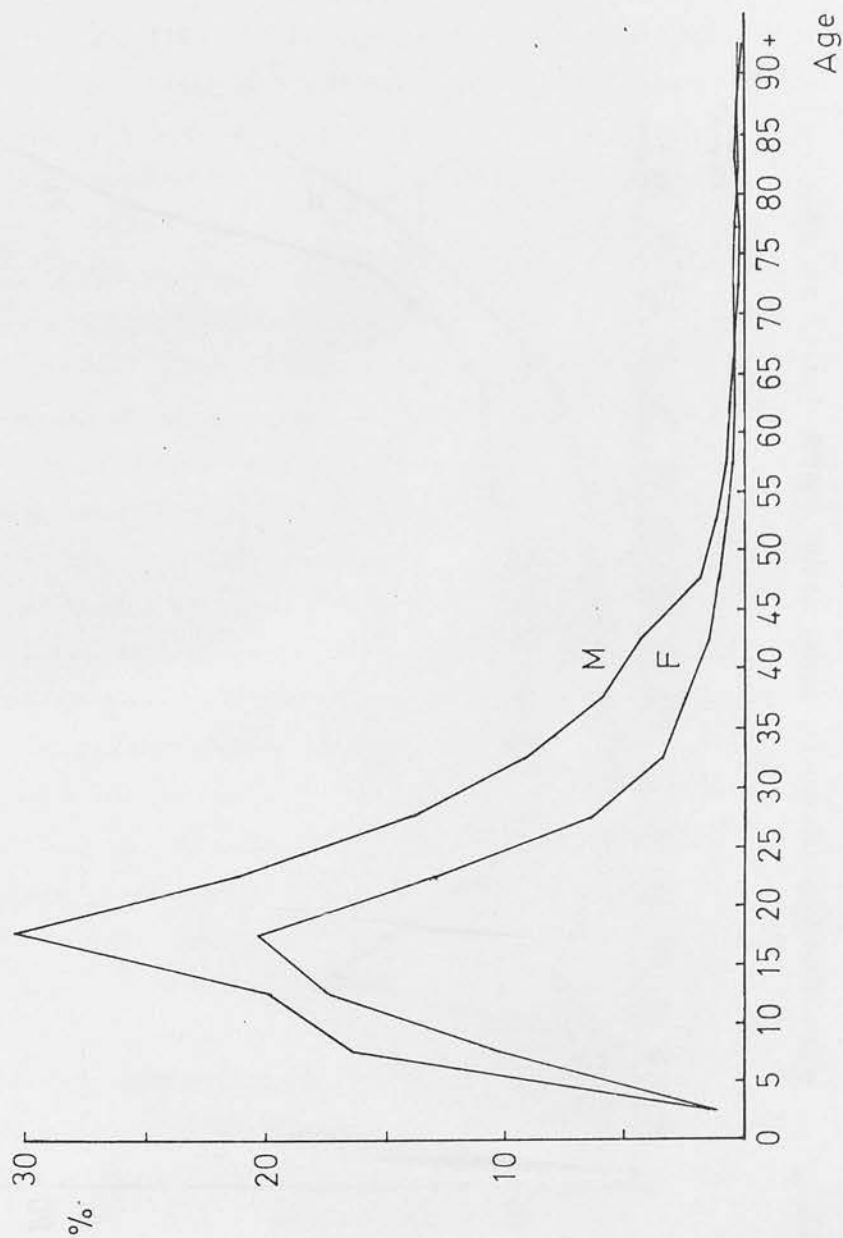


Figure 2.3 Deaths from Head Injury as a percentage of all deaths in each age-group in 1980 : England and Wales

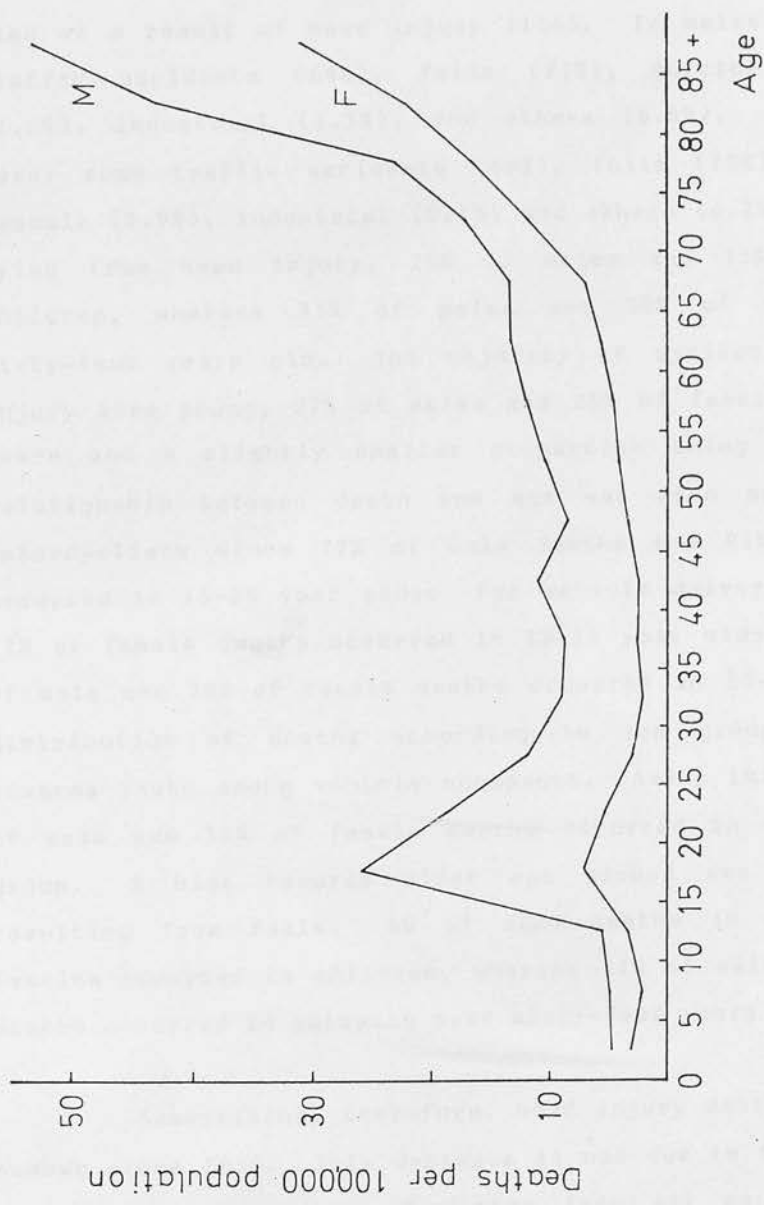


Figure 2.4 Age-specific mortality rates from Head Injury in 1980:
England and Wales

Traffic deaths (E819-E823) due to head injury in 1974 totalled two thousand, eight hundred and eighteen in England and Wales (115). In 1980 this figure had fallen to two thousand, seven hundred and fifty-three (116). In regard to motorcyclists only, the average number of deaths per year has been decreasing since 1958 and the percentage of these deaths, which were due to skull fracture, has also been decreasing (117).

In 1980 in England and Wales, two thousand, nine hundred and seventy males and one thousand, four hundred and fifteen females died as a result of head injury (116). In males causes were: road traffic accidents (64%), falls (21%), suicide (3.7%), homicide (2.6%), industrial (1.3%), and others (8.4%). In females causes were: road traffic accidents (60%), falls (28%), suicide (2.8%), assault (2.9%), industrial (0.1%) and others (6.2%). Of pedestrians dying from head injury, 20% of males and 15% of females were children, whereas 33% of males and 58% of females were over sixty-four years old. The majority of cyclists dying from head injury were young, 27% of males and 28% of females being aged 5-14 years and a slightly smaller proportion being 15-24 years. The relationship between death and age was even more striking among motorcyclists since 77% of male deaths and 81% of female deaths occurred in 15-24 year olds. For vehicle drivers, 37% of male and 27% of female deaths occurred in 15-24 year olds and a further 37% of male and 38% of female deaths occurred in 25-44 year olds. The distribution of deaths according to age group was more biased towards youth among vehicle occupants. Among this latter group 56% of male and 35% of female deaths occurred in the 15-24 year old group. A bias towards older age groups was evident in deaths resulting from falls. 6% of such deaths in males and 3.5% in females occurred in children, whereas 41% of male and 73% of female deaths occurred in patients over sixty-four years old.

Summarising, therefore, head injury deaths have declined in number since 1950. This decrease is not due to the aging population (19). The proportions of deaths from all causes, of accidental deaths and of road deaths which result from head injury have

decreased since 1972. This applies to both England and Wales and to Scotland (19). The decline in head injury deaths has not been uniform since deaths due to post-traumatic intracranial haematoma, particularly in females, have increased. Also, the overall decline has been less marked in females than in males. Head injuries remain the commonest cause of death in young people.

2.1.17 EPIDEMIOLOGY FROM THE REST OF THE WORLD:

a) AUSTRALASIA:

Most of the Australian studies and the only study from New Zealand that I propose to consider deal exclusively with road traffic accidents. Selecki and others have, however, considered all causes of neurotrauma (118, 119, 120, 121, 122, 123) and I will examine these to begin with. During the six years between 1960 and 1965, eleven hundred and twelve patients with injuries to their head or spine were admitted to two teaching hospitals for periods of twenty-four hours or more (118). This group of patients included nine hundred and ten with head injuries and was studied retrospectively by Selecki et al (118, 119). Head-injured patients were admitted under the care of various specialists, 43% under the care of neurosurgeons and 10% under the care of general surgeons (118). During the course of the period studied head injuries increased on average by 25% per annum (119). Head injury and admission policy were not defined. 55% of patients were admitted within twenty-four hours of injury and 75% within one week, however 5% were admitted more than one month after injury and slightly more than 1% were admitted one year or more after injury (119). These latter characteristics suggest a mixed population of patients, perhaps intermediate between an unselected group admitted to primary surgical wards and those admitted to neurosurgical units in the United Kingdom. The male/female ratio was 2.5 overall and approximately 15% were in the first decade of life, whereas about 10% were sixty years old or older (119). Patients in the second decade of life were heavily over-represented when compared to the general population and accounted for 26% of head injuries. Patients in the third decade were also over-represented although to a lesser extent, and accounted for 20% of admissions. All other age groups were under-represented and this was particularly so in older patients, thus patients aged 70-80 years accounted for only 3.1% of head injuries but made up 4.6% of the general population, an under-representation of 32%.

Social class was not considered as such, however, a large proportion were labourers (118) and when grouped with craftsmen, accounted for 32% of head injuries despite forming only 22% of the general population (119). By the same token, housewives accounted for only 35% of their predicted number based on their proportion in the population, business and clerical workers totalled 62% and pensioners 75% of their predicted number. Alcohol was related to head injury in 14% overall but in 30% of those aged 20-60 years and about a quarter of those over sixty years. However, one half of patients involved in brawls had alcohol mentioned in relation to their injury compared with 12% of patients injured at home, 10% injured in road traffic accidents, 7% injured during sporting activities and 6% injured at work (119).

The causes of head injury were: road traffic accidents 39%, home accidents 17%, sport 11%, brawls 9%, industrial 7% and others 17%. (119). During the study period injury due to sports accidents and brawls increased significantly, 4.5 times and nine times respectively for all causes of neurotrauma (118), whilst industrial injuries decreased (119).

In 15% of head injury admissions there was no record regarding loss of consciousness in the case notes (119), 53% suffered no loss of consciousness, 20% were unconscious for up to thirty minutes, 2% for between thirty and sixty minutes, 5% for more than one hour but less than twenty-four hours, 4% for one day to two weeks and 1% for longer than two weeks. Skull fractures occurred in one hundred and forty-four patients (16%) and of these, eighty-three were linear fractures, twenty-five were depressed, thirteen were compound, twelve basal and eleven comminuted. Fractures of the facial bones occurred in one hundred and thirty patients (14%) while sixty-eight (7.5%) had limb fractures, ten (1.1%) had pelvic fractures and five (0.5%) had spinal fractures (119).

The average duration of stay in hospital following head injury was 13.6 days (118). About two thirds spent less than two weeks in hospital, 42% stayed less than three days and only 3.4%

stayed more than three months (118). 89% of patients were discharged without any disability (119); 2.8% (26 patients) were discharged with mild neurological and mental deficits; 0.3% were discharged with moderate deficit and 1.6% with severe deficit. Post-traumatic epilepsy occurred in 0.5% and 5.7% of patients died. Mortality was more than four times as high in those with skull fracture (15%) as in those without (3.5%) and was also higher in patients with gunshot wounds, basal fractures or comminuted fractures (119).

Intracranial collections of blood occurred one hundred and thirty-five times among one hundred and eleven patients (119). Sixty-eight patients had a subdural haematoma, thirty-one had intracerebral haematomas and fifteen had an extradural haematoma. The ratio between these three conditions was 4.5:2.1:1 and the incidence for the six year period was 74/1000 admissions for subdural haematoma, 34/1000 admissions for intracerebral haematoma and 16/1000 admissions for extradural haematoma. The catchment population was not given so that true incidence figures cannot be calculated. Also, the total for subdural, extradural and intracerebral haematomas (114 lesions) is less than the total stated for all traumatic intracranial collections of blood (135 haematomas). No reason for this discrepancy can be arrived at from the data presented. Mortality was 34% for patients with subdural haematoma, 40% for patients with extradural haematoma and 42% for patients with intracerebral haematoma.

In a separate communication (120), the same author considered in further detail those patients from the above group who were injured in road traffic accidents. Three hundred and fifty-five such patients had head injuries, 60% were vehicle occupants and 26% of this group were aged 17-20 years. Pedestrians accounted for a quarter of the head injuries from road traffic accidents, nearly a third were under ten years of age and more than a fifth were over sixty years of age. 5.6% of patients were motorcyclists and 9% were cyclists, the majority of both groups being in their second decade of life. Approximately 30% of patients

with head and spinal injury following a road traffic accident had other serious injuries, about 15% having fractured limbs and 1% having both head and spinal injuries. More than a fifth of patients over ten years of age and admitted within twenty-four hours of the accident had recently consumed alcohol. The overall mortality was 6.2% but was 12% amongst pedestrians.

Ten years after the above work was published, one of the original authors in conjunction with others, compared the initial group of patients with a smaller group of one hundred and seventy-nine head-injured patients admitted to the same hospital during 1975 and 1976 (121). Again the study of the latter group was retrospective and an unknown number of patients were excluded, when it was thought that other associated injuries were more important than the head injury, also, many records were unavailable though it does not say how many. 43% were admitted more than twenty-four hours after injury. The latter group comprised one hundred and thirty-three males and forty-six females (male/female ratio 2.9), 45% were twenty years old or less and 8.4% were sixty-one years old or over. Once again manual workers were over-represented. Road traffic accidents accounted for 31% of head injuries, home accidents 16%, sport 12%, brawls 6.7% and industrial accidents 5.6%. Other and unrecorded causes accounted for 29%. Over 70% of road traffic accidents occurred in 11-30 year olds with a male/female ratio of 5:1, about half of home accidents occurred in children under ten years of age with a male excess and nearly all sports injuries occurred in 11-20 year old males. All assaults occurred in 11-40 year old males. Neurosurgeons cared for 72% of this group compared with only 43% in the first group (118, 121).

In the first series, 16% of patients had a skull fracture and about a sixth of these were depressed, whereas in the later series 38% had a skull fracture and more than a third were depressed. No initial loss of consciousness occurred in 45% of the later group and 53% of the first series. However, in a fifth of the later series there was a lack of information about the duration of unconsciousness. The proportion of patients with extradural

haematoma rose from 1.6% to 8.4%, of subdural haematoma from 7.5% to 27% and of intracerebral haematoma from 3.4% to 5% between the two series. The overall mortality in hospital was 8.9%, more than two thirds dying within one week, compared with 5.7% in the first series; and was higher after road traffic accidents, if a skull fracture was present, and in older patients.

Many criticisms can be levelled at this series of papers. They suffer from the recognised drawbacks of being undertaken retrospectively, head injury and admission policy were not defined. In addition the proportion of patients who were secondary referrals was not given, nor were the numbers of patients excluded for whatever reason. The early and later series are not comparable because of the exclusions from the later group. Conclusions, therefore, based on comparison between the two cannot be made. Finally, the papers are littered with simple mathematical errors.

In an earlier study covering the five years immediately preceding Selecki's original work, Fay (124) reported a retrospective series from Tasmania. Over 95% of the victims of accidents occurring in the catchment area and 99% of the seriously injured were considered to attend the only hospital in the area and from which the report originated. The total number of cases identified was 1,402 and included one hundred and three patients (7.3%) who were dead on arrival. Head injury was defined according to seven categories and except for those brought in dead all cases had been admitted, although only a sketchy outline of admission policy was given by the author. Insufficient population details were provided to allow incidence rates to be determined. Likewise details of age and sex were not given and there was little indication of causes. The common association between alcohol and head injury was alluded to. Skull fractures were present in about a third. The proportion of patients alive on admission (1299) who had extradural haematoma was 0.2%, of subdural haematoma was 1.0% and of combined haematomas, including intracerebral lesions was 1.1%. The overall mortality was 13% and of those alive on admission was 5.9%. Almost three-quarters of all deaths and 42% of deaths in those

patients alive on admission occurred within twelve hours. Mortality was higher in patients with more severe head injury and in patients with extracranial injuries. All of the nine deaths in the concussed group were due to associated extracranial injuries.

Selecki et al (122, 123) in two further papers described the epidemiological features of neural trauma occurring in New South Wales during 1977. All post mortem reports for death due to trauma occurring during the study period were examined (122). Trauma was defined as those external causes of injury corresponding to the International Classification of Diseases (8th Revision) E800-E999 with the exception of those cases due to poisonings, burns and drowning. Ancillary information was gathered from the police, transcripts of inquests and death certificates. Hospital data was abstracted from State Hospital In-patients Statistics. Diagnostic and procedure codes for neurotrauma were defined. Only primary diagnoses were coded so that patients in whom head injury was of secondary importance would be omitted. This latter would lead to an underestimation of incidence. Over-estimation also resulted since patients transferred between hospitals were counted as separate admissions. Such an over-estimation is unlikely to be great, but the underestimation is likely to be significant.

Head and spinal injury deaths numbered fourteen hundred and two in 1977 and detailed analysis of twelve hundred and eighty-seven (92%) was possible (122). For the population of New South Wales neurotrauma was the commonest cause of death up to the age of forty-four. In males and in rural areas it was the commonest cause of death in those aged up to forty-nine years. Most deaths, the highest mortality rate and the highest proportion of all deaths occurred in those aged 15-24 years, when 45% of all deaths were due to neurotrauma. Neurotrauma accounted for 60% of all deaths due to trauma, 71% of traffic deaths (67% of vehicle occupant deaths and a higher proportion of deaths in pedestrians, cyclists and motorcyclists), half of all accidental deaths and 46% of deaths from all external causes (E800-E999). In children aged 0-4 years, 89% of all trauma deaths resulted from neurotrauma. The proportion

in each age group thereafter declined to a minimum of 24% in patients over seventy-four years old. Trauma to the head and spine caused 8% of all lost years of life and 17% of lost years of working life (122).

For those dying the male/female ratio was 3 (122). The overall mortality rate was 28/100,000 and peaked in 15-24 years olds (49/100,000 in females and 74/100,000 in males). In men aged over seventy-four years the rate was 75/100,000. For the 92% of deaths with full information, road traffic accidents accounted for 66%, suicide for 12% and falls for 9%. In rural areas death resulted from road traffic accidents in 74% and in urban areas in 60%. Pedestrian deaths were more than twice as common in urban as in rural areas. 64% of traffic deaths occurred prior to arrival at hospital and this proportion was higher in rural (75%) than in urban areas (54%). 40% of all deaths occurred in rural areas although only 28% of the population lived in those areas. For all types of injury, immediate death occurred more often in rural areas (60%) than urban areas (35%). Of those alive on arrival at hospital, three fifths died within forty-eight hours and four fifths in the first week (122).

For those patients with full information, 40% of deaths resulted from intracranial haemorrhages, 50% from all other types of head injury and 10% from spinal injury (122). Deaths due to intracranial haemorrhage occurred in 64% of falls and 41% of traffic accidents. The proportions in the latter group were: pedestrians 47%, drivers 38%, motorcyclists 40% and passengers 41%. Multiple associated injuries occurred in 33% of those dead on arrival at hospital and 26% of those dying after arrival. More than half of those dying from multiple injuries had, in addition to head injury, injuries to the spinal cord or spine, chest or abdomen. 37% had combined head and chest injuries, 7% had head and limb injuries and less than 1% had spinal cord and other injuries in the absence of head injury. Multiple and basal skull fractures occurred in 39% of those dead on arrival at hospital and 23% of later deaths.

Blood alcohol levels were measured in 37% of those who died and levels greater than 79mg% occurred in a third. Raised levels were much commoner in men and in rural areas. A quarter of those involved in falls and a third of suicide cases had a level of 80mg% or more and such levels were also found in 49% of rural drivers compared with 40% of urban drivers. For car drivers dead on arrival, 44% of urban and 54% of rural drivers had excessive levels. For those with alcohol levels of 80mg% or more, a third had a level of 80-159mg%, a third had a level of 160-239mg% and a further third a level of 240mg% or more (122).

From the hospital study, twenty one thousand nine hundred and seventy-three admissions for neurotrauma were identified and eighteen thousand, six hundred and seventy-nine (85%) of these were for head injury, the male/female ratio for head injury admissions being 2.1 (122). The highest number of admissions was in the 15-24 year old age group. The admission rate for all patients was 443/100,000, was highest in 15-24 year olds (785/100,000) and next highest in 0-4 year olds (578/100,000). An estimate for A&E attendances with neurotrauma in the same state during the same year was 130,000. Road traffic accidents accounted for one third of admissions and were most common in 15-24 year olds and in rural areas. Falls caused 29% of admissions and were commonest in the very young and very old. Industrial accidents accounted for 10% and brawls and assaults 6%. Overall, 40% of admissions occurred in rural areas, where 28% of the population lived. Using length of stay as an indirect measure of severity, seven hundred and fifty patients (4%) with head injuries suffered permanent disability and two thirds of these were male, 30% were aged 15-24 years, 60% were injured in road traffic accidents and 40% were from rural areas. The average length of stay for all patients with neurotrauma was 6.7 days but nearly a half of those with head injury stayed less than twenty-four hours. Neurotrauma accounted for 2.2% of all hospital admissions and 1.5% of occupied bed days in 1977. As regards cost, the total arrived at was nine hundred and forty-nine million Australian dollars or four thousand three hundred and nineteen dollars per patient admitted (122). For individuals aged 15-24

years the average cost of lost production per person was over four hundred thousand Australian dollars (£1 = 1.74 Australian dollars on 12th April, 1983).

In an accompanying paper the same authors detailed the descriptive statistics of the surgical treatment of neurotrauma in the same year (123). Seven hundred and forty-seven head-injured patients (4%) underwent surgical procedures. The mean length of stay in all head-injured patients was five days, and eighteen days in patients undergoing surgery. The latter group accounted for nearly a fifth of all neurosurgical procedures involving the head. For all neurotrauma patients the male/female ratio of those undergoing surgical procedures was 2.4 while a quarter of such procedures were carried out in patients aged 15-24 years. For head-injured patients the male/female ratio was 3. All neurotraumatic surgical procedures constituted 0.3% of the total number of surgical procedures in the same year. They accounted for 0.5% of surgical bed days with a mean duration of stay of 11.9 days compared to 6.7 days for all surgical procedures. Road traffic accidents and industrial accidents each accounted for 27% of neurotraumatic procedures, although accounting for 34% and 10% respectively of all neurotrauma admissions. However, the majority of surgical procedures following industrial accidents were for peripheral nerve injuries. 91% of surgical procedures on head-injured patients were undertaken in urban hospitals. Although rural areas had a disproportionately high number of head injuries in general, urban residents were more likely to have a neurosurgical procedure performed. Neurosurgeons treated 11% of all neurotrauma admissions, but carried out 39% of all surgical procedures for neurotrauma. For head-injured patients, neurosurgeons treated 11%, but undertook 60% of surgical procedures for neurotrauma, the remaining 40% being undertaken by general, orthopaedic and plastic surgeons (123).

The injury pattern in nine hundred and eight fatalities from road traffic accidents occurring between 1963 and 1968 in Brisbane was reported by Tonge et al (125). The catchment

population for these deaths was seven hundred thousand, indicating a mortality rate of 26/100,000 per annum. However, some patients died after transfer from areas outside the catchment area and some post-mortems were referred from adjacent coroners so that this mortality rate is higher than the true rate. All patients dying after road traffic accidents had a post-mortem, nearly always macroscopic only. All patients over fourteen years of age who died within twelve hours of receiving their injury had their blood alcohol measured. Of all deaths, 39% occurred in pedestrians, 28% were car drivers, 22% were car passengers, 6.2% were motorcyclists or scooterists and 4.1% were cyclists. The male/female ratio was 2.8 overall but 40:1 for motorcycle riders, 1:1 for pillion passengers, nearly 10:1 for car drivers and 6.4:1 for cyclists. Two fifths were less than twenty-five years old and nearly a fifth were aged sixty-five years or more. However, nearly three quarters (71%) of motorcyclists were males aged 15-24 years whereas 11% of pedestrians were under ten years of age and a third were over sixty-four years of age. Of cyclists, 46% were 10-19 year old males. 37% of all fatal accidents occurred at the weekend with 22% on Saturday night alone, most occurring between 18.00 and 21.00 hours with a further, lesser peak at 24.00 hours.

Superficial but severe head injury occurred in 81% of all patients, with skull fractures present in 49% (73% motorcyclists, 70% cyclists, 50% pedestrians, 48% car passengers and 40% car drivers) (125). 48% had brain injuries, again these being more common in cyclists (73%) and motorcyclists (63%). Overall, contusions were commoner than lacerations. Intracranial haematomas, mostly in combination, occurred in 62% with motorcyclists (80%) having the highest and car drivers (53%) the lowest incidence. The ratio of subdural haematoma to extradural haematoma was 15:1.

Chest injuries were commonest in vehicle occupants and least common in cyclists. Abdominal injuries were also commonest in vehicle occupants and least often found in cyclists. Spinal injuries were most often cervical and least often lumbo-sacral, and were commonest in pedestrians and car passengers. Pelvic fractures

were commonest in pedestrians and were more than twice as common in these patients (33%) as in the group with the next highest incidence (car drivers 15%) and six times as common as in motorcyclists, who had the lowest incidence (5%). Limb fractures were also commonest in pedestrians and were least often found in cyclists. Significant haemorrhage occurred in nearly a third of all deaths although the contribution this made to death could not be determined. 4.1% showed inhalation causing suffocation although the authors considered this to be an underestimation (125).

There was an average of 5.8 significant injuries per patient with a range from 4.8 for cyclists to 6.3 for pedestrians and an almost equal incidence in vehicle occupants and motorcyclists of about 5.4. Between 1963 and 1968 the incidence of head injury relative to all other injuries significantly decreased for all patients and for pedestrians, the same being true of abdominal injury both for all patients and for car passengers as a separate group. The decrease in the incidence of head injury was associated with a significant decrease in the incidence of intracranial haemorrhage without significant decrease in the number of skull fractures or brain injuries (125).

52% of patients died within one hour (62% car drivers, 57% car passengers and 46% pedestrians), 66% died within six hours, 70% within twelve hours and 75% within twenty four hours. 90% died in the first week and only 4% survived for more than one month. Seven hundred and seven patients (78%) had their blood alcohol level estimated and 29% had levels of more than 100mg%. This was the case in 46% of car drivers and was even higher (68%) in drivers involved in single car crashes, especially in those aged 30-39 years (93%) and 40-60 years (83%). Altogether, 63% of patients treated had no alcohol detected. Cardiovascular predispositions were concluded to account for 6% of fatalities among car drivers, only one in four of them having any serious injuries and none involved other vehicles or people. Where the information was known, only 2% of car occupants had worn seat belts. Similarly, only 7% of the deaths among motorcyclists and scooter riders occurred in patients known to have

been wearing crash helmets (125).

Hossack (126) also described the pattern of injury among the victims of road traffic accidents, although he confined himself to vehicle occupants. He reported on five hundred fatalities occurring in a five month period at the beginning of 1970. They comprised three hundred drivers and two hundred passengers. The overall male/female ratio was 3.5 (11.5 for drivers and 1.3 for passengers). 23% of drivers died from head injuries alone, 15% from a combination of head and chest injuries and 20% from multiple injuries. 29% of passengers had head injuries alone, 9% had head and chest injuries and 17% had multiple injuries. Head injury occurred in 57% of all vehicle occupant deaths. Skull fracture was present in 46% of drivers and 34% of passengers and brain damage occurred in 45% of the whole group. 7% of victims died of asphyxia with no serious trauma present and even more had inhalation of blood and vomitus which contributed to death.

In a further publication related to two of the earlier papers in this section, Simpson et al (127) reported on fatal injuries of the head and spine occurring in the states of New South Wales and South Australia during 1977. These deaths included those already detailed (122) for New South Wales together with three hundred and twenty-five deaths occurring in South Australia. The methods of selection were clearly defined. However, details of one hundred and fifteen deaths (8.2%) in New South Wales were unavailable and a quarter of the three hundred and twenty-five deaths in South Australia did not have post-mortem examinations.

The authors felt that omission of details in the New South Wales group (1402 deaths) did not introduce any bias into their data. Using the mid 1977 population statistics the crude mortality rate in males (423/1,000,000) in New South Wales was significantly higher than the crude mortality rate in females (143/1,000,000) and the same was true of South Australia (males 388/1,000,000 and females 122/1,000,000). Non-residents accounted for 6% of the New South Wales and 4% of the South Australian deaths. In both states

the male/female ratio was 3 and the male excess was evident irrespective of the cause of injury. The majority of victims were young and among 15-24 year olds neurotrauma accounted for 45% (NSW) and 51% (S. Aust) of all deaths in that age group. Among both sexes mortality rates rose to a peak at 15-24 years (500/1,000,000) and then declined before rising again in those aged seventy-five years or more (431/1,000,000). Neurotrauma was the leading cause of death from 0-44 years in both states accounting for at least one fifth of all deaths. Victims of road traffic accidents were generally younger and 79% of car drivers were aged 15-44 years whereas 73% of those dying as a result of falls were over forty-four years old. Spinal injuries accounted for 10% of neurotrauma deaths in New South Wales and 6% in South Australia. Intracranial haemorrhage of all types accounted for 36% of all neurotrauma deaths in the two states, other types of head injury for 54% and spinal injuries for 9%. In South Australia, surface intracranial haematomas accounted for thirty-three deaths (10% of all and 11% of head injury deaths) and in nine cases were the result of extradural haemorrhage (127).

For head injury deaths the mortality rate from road traffic accidents (168/1,000,000) was five times that for the next commonest cause, suicide (31/1,000,000). The causes of death in head-injured patients were: road traffic accidents (66%), suicide (12%), falls (8.7%), trains (3.5%), homicide (3.1%), industrial (2%) and others (4.3%). Dividing traffic accidents further, car drivers (38%) accounted for most neurotrauma deaths. For other types of road users the proportions were: passengers 24%, pedestrians 23%, motorcyclists 13%, cyclists 2% and other 1%. For all road accident deaths neurotrauma was the commonest single cause, accounting for at least two thirds of all such deaths (127). The mortality rate for neurotrauma was significantly higher in rural areas. In New South Wales 53% of all fatal injuries occurred within 50 kilometres of neurosurgical units, 13% from 51-100 kilometres distant, 13% from 101-200 kilometres distant and 0.9% more than 800 kilometres from the neurosurgical units. In South Australia the findings were similar. Deaths following falls were commoner in urban areas (79%) and deaths following road traffic accidents commoner in rural areas

(57%) (127). Death occurred before arrival at hospital in 65% of the New South Wales series and 71% of the South Australia series. In South Australia, 5.8% talked before they died and in two thirds of these death resulted from intracranial bleeding.

Alcohol levels were measured in 40% of all those dying in New South Wales and 56% in South Australia. The higher proportion tested in South Australia may be explained by the fact that in that state alcohol estimations were mandatory in all cases of road traffic accident resulting in death or hospital admission if the patient involved was aged fourteen years or more. For all deaths where alcohol levels were measured, a third had levels of 80mg% or more. Such levels were higher in road accident victims (36%) and suicides (39%) than in those who were the victims of falls (27%). Car drivers had the highest proportion (44%) of excessive alcohol consumption. This paper together with those of Tonge et al (125) and Hossack (126) can be compared with the British studies by Ruffell Smith (100), Sevitt (101) and Whittington (102).

Petty (128) showed a lessening of the severity of head injury before and after the introduction of legislation in Melbourne to make the wearing of seat belts compulsory. The patients in his study were admitted to hospital one to two years before and one and a half to two and a half years after the legislation became effective and consisted of one hundred and sixteen patients in the former and one hundred and forty-two in the latter periods. Division of patients into groups with mild or severe head injury was undertaken and each type was defined. Severe head injury in vehicle occupants declined from 47% to 14% while the total number of head injuries increased. There was also a decline in severe head injury from other causes between the two periods, from 41% to 22%. However none of the patients in the two periods were recorded as having worn seat belts or not. Surveys independent of this study showed more than a 70% compliance with the law.

Blood alcohol analysis in road traffic accident victims in New Zealand has been studied by Hart et al (129). Only drivers

attending accident and emergency departments within four hours of their accident and who had not consumed alcohol since the accident were included. During a three month period in 1972, four hundred and sixty-one car drivers and motorcyclists were available for study. Social classes IV and V were significantly more often involved in road traffic accidents. Ninety-one patients were not sampled because: eight refused, in fifteen the time of the accident was unknown, in forty-seven more than forty-eight hours had elapsed since their accident and twenty-one had either been drinking since their accident or had more urgent priorities present. Recent alcohol consumption was shown in 27% and in 19% of all those sampled the level was more than 100mg%. More than two thirds of those with any alcohol present were involved in single vehicle crashes against an expected 38%. Significantly more patients with alcohol present had previous traffic, criminal or drinking offences. Positive blood alcohol was commoner in admitted patients and in those who were dead on arrival at hospital, and was significantly associated with more serious injury. 63% of all positive blood samples were in 15-25 year olds. There were more positive results at weekends, late at night and in accidents where the driver was considered to be solely responsible for causing the accident. Positive results were commoner in social classes III, IV and V. In common with Britain (85) nearly a third of all accidents known to hospitals were unknown to the police.

Analysing traffic accidents in Melbourne based on a sample of one hundred crashes involving three hundred and ten people, Ryan (130) found that 58% of crashes involved cars only, 22% pedestrians and 11% motorcyclists. Nineteen patients were excluded because of lack of information and of the remainder, one hundred and eight were uninjured. 70% of those with any injury had head injuries of varying degrees of severity and there were an average of 2.2 injured body areas per patient. No patient wearing a seat belt had more than minor injury. On the basis of clinical assessment only, 32% of people involved in accidents had recently consumed alcohol and this was most common during the evenings and on Friday and Saturday nights when most accidents occurred.

In many respects, these results from the Southern hemisphere are comparable with those from Britain and also as we shall see, with results from the rest of the world. A striking difference is noticeable in the mortality rate for head injury. In England and Wales in 1976 the mortality rate for head injury was 9.2/100,000 (19) and in New South Wales in 1977 was 25/100,000 and in South Australia 24/100,000 (127). In 1977 for motor vehicle accidents alone the mortality rate in Australia was 27/100,000 and in the same year in England and Wales it was 12/100,000 (122). It is difficult to explain this much higher rate in Australia, especially as in most other respects epidemiological characteristics are very similar to those reported in Britain.

b) CANADA:

Several papers detailing the epidemiology of head injury have been published by Klonoff and others (48, 49, 131, 132, 133). Four of these were confined to children (49, 131, 132, 133) and in these intellectual, electro-physiological and neuro-psychological findings have been emphasised (49, 132, 133). Hendrick et al (134) have also reported on head injuries in Canadian children and logically have included head injury due to birth trauma in their large series, although by convention these have not been included in other series. None of these studies permit accurate incidence rates to be determined.

Klonoff and Robinson (131) quoted national statistics for Canada in 1961 when eight thousand, four hundred and eighty-nine patients aged less than fifteen years were discharged with diagnoses described by ICD rubrics N800-N804, N850-N856. For British Columbia the number of 0-9 year old children admitted with head injury in 1963, 1964 and 1965 were 846, 899 and 938 respectively.

The earliest of the above studies was that by Hendrick et al (134) who described four thousand, four hundred and sixty-five children under fifteen years old who were admitted to neurosurgical wards in the eight and a half years up to July 1962. Two hundred

and seventy (6%) of these cases were due to birth injury, of whom about a third had subdural haematoma and one hundred and twenty-one died. No definition of head injury or indication of admission policy was given. It seems likely that a number of patients were secondary referrals, 13% were admitted more than twenty-four hours after their injury while the average elapsed time for those admitted within twenty-four hours of the accident was five hours. Extradural haematoma and subdural haematoma were defined as pure haematomas i.e., not associated with brain damage. The characteristics of the patients when further defined would indicate a selected population intermediate between that admitted to general surgical wards in Britain and those transferred to a neurosurgical unit. Bearing in mind the above, this series had the expected male excess of patients (male/female ratio 2.1) with a peak in girls aged four years and boys aged six, similar to Partington (63) and Jamison and Kaye (62). As with British studies of children, falls were the commonest cause of head injury (53%) followed by road traffic accidents (32%). Of the latter, four fifths were pedestrians and road traffic accidents were responsible for 52% of deaths excluding birth injury. Falls peaked at under one year and then steadily declined, while road traffic accident injuries peaked at five years of age.

A history of unconsciousness at the time of injury became more common as age increased. 35% had no history of unconsciousness and this finding occurred in 37% of those who developed subdural haematoma, 29% of those who developed brain damage and 2.6% of those developing extradural haematoma, while 11.5% of those with no history of unconsciousness died. 25% had a history of drowsiness, confusion and irritability and this occurred in a third of those with extradural haematoma and a quarter of those with subdural haematoma. None of those with extradural haematoma had a history of unconsciousness followed by full recovery, while this occurred in 10% of those with subdural haematoma and 13% of those with brain damage. 49% with extradural haematoma had a history of delayed loss of consciousness. On admission 56% of patients were fully conscious, 30% drowsy, irritable or confused, 4% comatose and the remainder had a variably depressed conscious level.

27% of patients had a skull fracture (90% were X-rayed within twenty-four hours of admission) compared with 10% of children admitted to general surgical wards in Britain (25), and 60% of all patients admitted to neurosurgical units in Scotland (29). Only 72% of those with a skull fracture had external evidence of head injury and in three quarters of these such evidence was ipsilateral. Linear fractures occurred in 73%. 27% of fractures were depressed and a fifth of all fractures were compound including cases due to birth injury. 85% of cases of subdural haematoma, 60% of cases of extradural haematoma and 35% of cases of brain damage had no fracture. Depressed fractures were especially common in patients with extradural haematoma and brain damage. Additionally, three out of thirty-nine patients with otorrhoea or rhinorrhoea had a fracture on X-ray and only twenty out of two hundred and forty-one with a haemotympanum or blood in the middle ear had a fracture on X-ray. 11.2% had other fractures, 82% of which were of the limbs, especially fractures of the clavicle and to a lesser extent of the femur. Only 0.16% had fractures of the cervical spine. Visceral trauma was uncommon but had a high mortality when it occurred. The incidence of extradural haematoma was 0.9%, subdural haematoma (excluding birth trauma) 2.3% and intracerebral haematoma 1%. Mortality (excluding birth trauma) was 2.9% of all cases, 10% of cases of extradural haematoma, 22% of cases of subdural haematoma and 41% of brain damaged patients. Overall 54% of those who died, did so on the first day. Mortality (excluding birth trauma) was highest in those under one year of age and steadily declined to a low level at 6-7 years and remained low thereafter.

Klonoff and Robinson (131) identified sixteen hundred patients aged 0-19 years with head lacerations and five hundred and eighty-seven patients aged 0-19 years with head injury attending the emergency department of a Vancouver hospital during a twelve month period between 1965 and 1966. Definitions of head injury and admission policy were omitted. Once again the expected male excess was evident (male/female ratio 2.3). In both groups, most patients attended in spring and summer and on Sundays more often than Saturdays, with fewer during the week. Only 1.6% of patients with

head lacerations were admitted. For children aged 0-15 years with head injuries, more than two thirds were under seven and most attended between mid-day and 18.00 hours or between 18.00 and 21.00 hours. 29% of this group of children were admitted. Peaks again occurred in spring and summer especially in 2-3 year olds. Of those aged up to nineteen years, 7% with head lacerations and 84% with head injuries had had skull X-ray. None of the patients with head lacerations died, whereas 0.3% of those patients with head injuries did.

Klonoff (49) was unable to show accident proneness was a factor in children with head injury except in so far as age and sex played a part. This is similar to the conclusion of Partington (63) in Sheffield. In addition, Klonoff found that head-injured children more often came from congested residential areas and lower income housing, that their fathers had a lower occupational status, and marital instability was commoner. These findings are similar to those of Moyes (64).

Klonoff and Thomson (48) described a group of adult head-injured patients (over fifteen years) who attended the emergency department or were admitted to neurosurgical wards in Vancouver General Hospital during 1967. Neither head injury nor admission policy were defined. Six hundred and thirty patients were described, three hundred and fifty-one who attended the emergency room and two hundred and seventy-nine who were admitted, although it is not clear what proportion of the emergency room patients were discharged or how many of the two hundred and seventy-nine admissions were primary admissions. Also, patients attending more than once with new head injuries were only counted once. For the emergency room patients the male/female ratio was 1.5 and for admissions it was 2:1. 53% of emergency room patients and 35% of admissions were aged 16-30 years. Most attended on Saturdays and there was only slight seasonal variation, the majority arrived between 17.00 hours and midnight. About two thirds of both groups arrived between 17.00 and 09.00 hours.

In both groups, road traffic accidents were the single commonest cause of head injury (44% of emergency room visits and 53% of admissions), and, very surprisingly, females out-numbered males in both groups. Falls accounted for 20% of emergency room visits and 23% of admissions with females out-numbering males particularly in the admitted group. Not surprisingly in industrial accidents (10% of emergency room patients and 11% of admissions) males greatly out-numbered females (2.5 and 14 times respectively). Similarly, males out-numbered females among those admitted after assaults (3.6% of admissions) but were about the same for emergency room visits (12.5% of all visits). Sport accounted for 5.1% of visits and 2.9% of admissions, with a slight excess of males in both groups. Fourteen patients died before being X-rayed. Skull X-ray was performed on 93% of emergency room patients and 89% of admitted patients. Skull fractures were present in 0.9% of the emergency room group and 27% of admitted patients compared with 3.1% of adult A&E attenders in Scotland (50) and 6% of adult admissions to general surgical wards in Scotland (25), again indicating, when taken in conjunction with other details e.g., incidence of intracranial haematoma or length of stay, the application of an admission policy leading to a selected group, intermediate between general surgical ward and neurosurgical admissions in Britain. None of the emergency room group died, however, 14% of those admitted did die. Multiple injuries and diagnoses other than head injury were present in 21% of the emergency room patients and in 37% of the admitted patients. Intracranial haematomas were present only in admitted patients, 8.6% had a subdural haematoma and extradural haematoma, 2.5% had subarachnoid haemorrhage and intracerebral haematoma. The median length of stay for those admitted was 6.9 days (CF.25).

It is apparent from these studies that in Canada patients are more often under the care of neurosurgeons than in the United Kingdom. Additionally, the incidence of skull fracture and intracranial haematoma, duration of stay and mortality would indicate that the severity of injury, the definition of head injury, the admission policy or some combination of these are not the same as in Britain. This would explain why the population of

head-injured patients in these papers consistently appears to be intermediate between a group of patients admitted to general surgical wards and one transferred to neurosurgical units in Britain. Why Canadian females should more often suffer head injury in traffic accidents than Canadian males is not clear, nor is it in keeping with findings in the United Kingdom. Nevertheless, the Canadian patients are broadly similar to British patients in many other respects.

c) EIRE:

Browne (135) recorded the experience of a neurosurgical unit in Dublin during 1972 and 1973. The two hundred and seventy-four admitted patients included secondary referrals although the proportion from each source was not stated. Head injury and admission policy were not defined, but included mostly the more severe type of injury. 32% were 0-10 years old and 22% were aged 11-20 years. The male/female ratio was 3:1 overall, but 2:1 in the 0-10 year old group. 85% of 0-10 year olds and all patients over eighty years of age were fully conscious or drowsy on admission, whereas only 9% of children, but more than a half of 60-80 year olds had more severe head injuries, as evidenced by their worse state of consciousness on admission. Mortality increased with age (24-45% overall) and decreasing level of consciousness. Alcohol consumption was noted in 27% of 30-70 year olds and 19% of patients over twenty years old. Road traffic accidents accounted for 45% of cases of head injury, play, leisure or sporting activities for 25%, home accidents for 16%, industrial accidents for 6%, assaults for 5% and other causes for 3%.

In children 90% of head injuries were the result of accidents at home or at play and only 10% were the result of a road traffic accident. 34% of patients had neurosurgical operations, thirteen (4.7%) for extradural haematoma, twenty-three (8.4%) for acute subdural haematoma and fifty-one (19%) for elevation of depressed fractures with a mortality of 38%, 69% and 9% respectively. Most children were discharged within forty-eight

hours. These results are comparable with those reported by Jeffreys + Azzam (56) and by Jennett et al (29) in Britain although overall mortality is somewhat higher despite including patients with less severe injury which would have a diluting effect.

d) FINLAND:

Concentrating on elderly patients only, Hernesniemi (136) described four hundred and twenty-four patients aged sixty years or more admitted to a neurosurgical unit during the period between 1971 and 1975. This group accounted for 17% of all the head injuries treated by the unit during the same period. At follow-up, only four could not be traced and all four had been well on discharge. All possible points of issue due to terminology were to some extent obviated by clear definition of the terms used. 59% were male and the male excess was most apparent in those aged 60-69 years, being absent in those of seventy-five years and over. Most cases were the result of falls (53%), followed by road traffic accidents (36%) of which two-thirds were pedestrians. Alcohol was noted on admission in 21%. A third had acute or chronic intracranial haematomas. Outcome was adversely affected by age, level of consciousness on admission, increasing length of unconsciousness and intracranial complications.

e) FORMOSA:

Two papers from Taiwan detail head injuries in all ages (137) and head injuries in children only (138). Chien (137) described one thousand and thirty cases of all ages admitted during a period of eight years ending in 1958. A fair indication of how the patients were selected was given and they accounted for 8.1% of all surgical admissions (14% of acute surgical admissions and a third of traumatic admissions). Overall mortality was 14%, 31% for a hundred and ten operated cases and 12% for nine hundred and twenty non-operated cases. Further analysis was confined to the non-operated cases, the male/female ratio being 5.4:1 in adults, 2.6 in children under fifteen years and 3.5 overall. 27% were under

eleven years of age and 17% were aged 11-20 years while 11% were over fifty years old. 60% of cases were due to road traffic accidents, 21% due to falls, 8% due to blows, and 4% the result of industrial accidents. Mortality increased with age and decreasing levels of consciousness on admission and more than half died within twenty-four hours. 25% of the latter five hundred and three patients in the series had a skull fracture and their mortality was 14% compared with 11% overall and 9.7% among those without skull fracture.

Kuo and Howng (138) identified two thousand, one hundred and thirty-six head-injured patients admitted during the years between 1958 and 1973. Three hundred and thirty-seven (16%) were aged 0-14 years, rather a low figure by British standards. The sex ratio among these children was 2:1. A little over a third were knocked out at the time of injury, 18% had a skull fracture, a third of which were depressed and 13% of those with a skull fracture died compared with 7.4% overall. The incidence of extradural haematoma was 3%, of subdural haematoma 1.5%, subdural plus extradural haematoma 1.5% and extradural haematoma and brain contusion 0.9% (extradural haematoma 5.3% overall).

Apart from the rather low proportion of all head injuries in the 0-14 year old age group in Kuo's series, the somewhat higher proportion of skull fractures in both and the larger proportion of injuries due to road traffic accidents in Chien's group, the results are compatible with those reported from Britain.

f) INDIA:

Five papers from India will be discussed. One of the five, by Kalyanaraman (139) does not give details of when the results included were obtained and is essentially a review of head injuries. However it seems likely that this paper includes an additional thousand patients presenting after the time period of an earlier paper describing cases of head injury of all ages (140). The latter paper detailed two thousand cases of head injury admitted to

neurosurgical wards during the two and three quarter years up to the end of 1969. All ages were included but no definition of head injury or admission policy was stated. Only 4% were admitted from accident and emergency departments, the remainder were secondary referrals from various sources, almost two thirds being referred by general surgeons in the same hospital. The male/female ratio was 8.2, 25% were aged 0-10 years, 27% were aged 11-20 years and 76% were aged 0-30 years with only 1.6% over the age of sixty. These figures show an exaggeration of the sex ratio and age-distribution found in the United Kingdom but may merely reflect the differences in the age-distribution of the general population. Also the fact that many were secondary referrals may have distorted the figures. Road traffic accidents were the commonest cause of head injury (42%) especially in the elderly (51% in patients over the age of fifty one) and adults (45% in patients aged 14-51 years). 6% of head injuries were the result of train accidents and nearly all of these occurred in adults. Assaults (11%) nearly all occurred in adults while other accidents (mainly falls) accounted for 39% (59% of children 0-13 years).

60% of all patients were fully conscious on admission and five died, one from multiple injuries, one from an extradural abscess, one from posterior fossa haemorrhage, one from aspiration of vomitus and one from traumatic meningitis. 4.2% were confused or disorientated on admission and four of these patients (4.8%) died, two from multiple injuries, one from recurrent subdural haematoma and one from bilateral acute subdural and intracerebral haematomas. 14% were able to obey simple commands and answer simple questions on admission and 3.5% of these died. The remaining 21% were unconscious on admission, of these 82% responded purposefully to pain, 8.1% became decerebrate in response to painful stimuli and 9.8% were unresponsive to pain. Nearly a quarter of those unconscious on admission died. Overall mortality was 1% in patients who were conscious to confused, 9% in patients who were semiconscious and 64% in patients who were comatose. Younger patients were more likely to be conscious on admission (61%) than older patients (51%). No initial loss of consciousness occurred in

16% of cases and more than two thirds of these were children, seven of whom died. Immediate initial loss of consciousness occurred in three quarters of all patients and was least common in children (65%). A lucid interval occurred in 1% overall and was associated with a 37% mortality. Mortality was twice as common in patients who suffered initial loss of consciousness (4.4%) as in patients not initially knocked out (2.1%). Of the group of patients not initially knocked out, one third of children, one sixth of adults and two fifths of elderly patients had a skull fracture. Whether the seven children not initially knocked out but who died had a skull fracture or signs on admission is not stated. Pupillary abnormality occurred in 12%, hemiparesis in 14% and dysphasia in 3%. Shock was present on admission in 1% of patients. Scalp lacerations were present in 45% of all patients, but in fewer children (31%).

Skull X-rays were performed in 99% of cases and 29% had a skull fracture. More than half were linear fractures and 85% of these were closed. Virtually one in four were depressed fractures, of which three quarters were compound. The remaining fractures were basal. Overall, fractures were more common in children, a little over a third of whom had a fractured skull. The incidence of extradural haematoma was 1%, subdural haematoma 1.8% and intracerebral haematoma 0.7%. Cerebro-spinal fluid rhinorrhoea and otorrhoea each occurred in 0.9% of cases. Post-traumatic convulsions occurred in 9.7% of all patients but in 14% of children.

The average duration of stay was 10.8 days, being less in children (7.4 days) than in adults (12.7 days) or elderly patients (13.8 days). Overall mortality was 5.8%, increasing from 4.2% in patients aged 0-10 years to 6.4% in patients aged 41-50 years, 13% in patients aged 51-60 years and 31% in patients over the age of sixty. Primary brain injury accounted for 59% of deaths, intracranial haematomas for a further 23% and intracranial infection for 4.3%. Multiple injuries and shock only accounted for 1.7% of deaths.

The characteristics and analysis of the patients described

indicate selection compared to the United Kingdom. Thus in this group, patients are more severely injured than in a group of admissions to a surgical ward in Scotland (25), although not as severely injured as patients transferred to a neurosurgical unit in the United Kingdom (29, 56).

Mentioning the age-distribution of three thousand head-injured patients, Kalyanaraman (139) found a much more British like distribution than in the two thousand cases described above, 35% were aged 0-13 years, 58% 14-50 years and 6% 51-90 years, the aetiology being about the same as for the former two thousand cases. Mortality increased with age and decreased levels of consciousness. 62% were fully conscious on admission and 0.4% of them died.

Jain and Kankanady (141) described a series of fifteen hundred consecutive cases of head injury admitted during an eighteen month period upto April, 1964. Neither head injury nor admission policy were defined. Children below the age of twelve years accounted for 43% of cases, 78% of cases were aged 0-30 years and only 2.7% were over sixty years old. The overall male/female ratio was 2.9 but was 7 in 21-30 year olds and was lowest at the extremes of life. Causes of injury were: falls 49%, road traffic accidents 35%, assaults 9.3%, blows from falling objects 5% and others 2.4%. Falls were particularly common in children (80% of causes in 0-10 year olds) and traffic accidents and assaults were common in adults (57% and 14% respectively of causes in 21-30 year olds). 85% of all cases were conscious to confused, 10% were semi-comatose and 4.9% comatose, although the point in time at which this applied was not stated. In these three groups mortality was 1.6%, 27% and 64%. Bradycardia occurred in 1.1% of all patients and more than three-quarters of these died. Pupillary abnormality occurred in 19% and was associated with an almost twentyfold increase in mortality. Hypovolaemic shock was present in 1.7% while a further 1% were considered to have shock due to primary vasomotor injury. Almost one in five patients had associated extracranial fractures, mostly of the limbs and mostly the result of traffic accidents. Vomiting

occurred in 17% of patients and over half of them were children. Convulsions occurred in 2.2%, lower motor neurone lesions of the seventh cranial nerve in 0.3%, all of whom had petrous temporal fractures and hemiplegia occurred in 2.8% of all patients (3.6% of children). Two fifths of all patients had lacerated, contused or incised wounds of the scalp and about one in seven had scalp haematomas, both being commoner in adults. All patients were X-rayed. Skull fractures were present on X-ray in 8.7% and were more common in children (12%) than in adults (6.2%).

Bleeding from the ears occurred in 5.7% of cases, only one-tenth of whom had a fracture seen on X-ray, and cerebro-spinal fluid otorrhoea was present in two cases. Eighteen basal fractures were evident only at post-mortem. Of the radiologically apparent fractures a little over one fifth were compound and nearly one in six of all fractures were depressed. Extradural haematomas occurred in eight cases (0.5%), two of these also had subdural lesions and one had both subdural and intracerebral haematomas. Subdural haematomas occurred in thirty-two patients (2.1%), two also had extradural haematomas, eight also had subarachnoid haemorrhage and ten had cerebral lacerations. Eleven (34%) of the cases with subdural haematomas had bilateral lesions including one patient with both extradural and subarachnoid bleeding. An intracerebral haematoma occurred in only one patient, but subarachnoid haemorrhage was present in seventeen cases (1.1%), meningitis in eleven cases (0.7%) and cerebral lacerations in twelve cases (0.8%).

Overall mortality was 7.3%, two-thirds died within twenty-four hours and 87% within seventy-two hours. Mortality increased with age, with worsening conscious level, in the presence of bradycardia and of pupillary abnormality as well as when a fracture was detected on X-ray.

One of the former authors (Kankanady) reported the characteristics of the six hundred and forty-one children in the above series separately although there was some disagreement between the two papers regarding the age range of these children (142).

Also the author used an alternative variation of his name. Head injury itself and admission policy were not clarified. The male/female ratio was 1.9 but nearer to 1 in younger patients. Slightly more were in the 5-10 year old age group (44%) than in the 0-5 year age group (42%). Females peaked at 3-4 years and males at 4-6 years. Falls accounted for nearly four fifths of all injuries and road traffic accidents one sixth. Two hundred and four patients (32%) were fully conscious on admission and 1% died, thirty-four (5.3%) were unresponsive to pain on admission and 79% died. Skull fractures were present in 12%. Nearly two-thirds were discharged within two days and only one in eight remained longer than a week. Mortality was 7.3%, three quarters dying within the first twenty-four hours. Post-mortems were carried out on eleven of the forty-seven who died and nine of the eleven had skull fractures, three had an extradural haematoma, six had a subdural haematoma, three had a subarachnoid haemorrhage and seven had cerebral lacerations.

Ghooi et al (143) described head injury in five hundred children under the age of sixteen admitted between 1965 and 1973. Head injury and admission policy were not defined, causes were apparently limited to falls, blows, and road traffic accidents, although assaults and miscellaneous causes appear in the table of causes. Badly decomposed bodies were excluded. The male/female ratio was 1.8, again being nearer to unity in younger patients (under five years). More were aged 5-10 years (47%) than 0-5 years (39%) or 10-15 years (14%). More than two thirds of the head injuries were the result of falls and nearly a quarter the result of road traffic accidents. 15% were shocked on admission, 51% were fully conscious and 16% made no response to stimuli of any kind. Intracranial haematoma occurred in 7% and skull fractures in 13%. The mortality rate was 8.8% and 96% died within twelve hours (twelve out of the forty-three who died within twelve hours were brought in dead).

g) NIGERIA:

Each of the university hospitals in Nigeria has reported a series of head injury admissions during the whole or part of 1974. Ohaegbulam (144) reported a retrospective series of one thousand and eighty-nine head injuries. All accident and emergency attendances were included, as were those dead on arrival at hospital. Head injury and admission policy were not defined. The incidence determined from this study was 272/100,000 per year, very similar to the United Kingdom (19). The male/female ratio was 2.6. 23% were aged 0-10 years, 22% 10-20 years, 33% 20-30 years and 11% were over forty years of age. Road traffic accidents caused 80% of head injuries, 13% were due to falls, 3% to assaults, 2% were domestic accidents and 2% industrial accidents. Of the road traffic accidents, one in seven involved pedestrians and most of these were children. Nearly a third of all cases had concussion, 3.7% had skull fractures, 0.1% had an extradural haematoma, 1.1% a subdural haematoma and 0.8% had an acute subdural hygroma. 9% died (82% were brought in dead or died in the department and a further 0.3% died on the first day), although patients who died from other injuries were excluded and only the seventeen patients dying after arrival at hospital were submitted for post-mortem examination. More males than females died, the male/female ratio being 4.5 compared with 2.6 for the whole series. Most of those who died were aged 20-30 years and 96% of deaths were the result of a road traffic accident. Of the seventeen in-patient deaths, three died from acute subdural haematoma associated with cerebral laceration, one died from an extradural haematoma, twelve died from bronchopneumonia and cerebral oedema and one died from an overwhelming head injury.

Adeloye et al (145) described five hundred and twenty-five patients admitted following head injury in the second half of 1974 in Ibadan. This was a prospective study, although again head injury was not defined and admission policy was not stated. The patients constituted 3.5% of all accident and emergency attendances, much lower than in Britain (17, 18, 19). The male/female ratio was 2.4. In ninety-seven adults the age was indeterminable. The vast majority of all patients were under ten years of age and significantly different proportions were aged 0-10 years, 11-20

years and twenty-one years or more. The age-distribution was not given and this statement could not therefore be confirmed. Most injuries occurred on Sundays and Mondays and 87% attended on the day of injury. Road traffic accidents caused 59% of head injuries, 25% occurred at home, only 2.5% occurred at work and 5.3% were assaults. Children were most often injured in falls at home or as pedestrians. 28% of all patients were knocked out at the time of injury while 87% were fully conscious on arrival at hospital. 83% had a skull X-ray and of these, 7.3% had a skull fracture. 58% were discharged within twenty-four hours and only 5% were admitted to the main hospital, all the remainder being detained in the accident and emergency department for observation. There were two cases of extradural haematoma, one case of subdural hygroma and one subacute subdural haematoma. The mortality rate was 3.5% (more than two thirds the result of road traffic accidents), nearly four fifths died after admission and within twelve hours (those brought in dead were presumably excluded). Mortality increased with deteriorating levels of consciousness.

h) NORWAY:

The details of alcohol consumption among head-injured patients in Norway have recently been described (146). All patients admitted during the years 1979 and 1980 were included provided they were over eleven years old and were admitted within twelve hours of their injury. Head injury was defined as trauma to the head leading to loss of consciousness, skull fracture or the development of an intracranial haematoma. Admission samples of blood were tested for alcohol and levels greater than 49mg% were counted as positive.

Four hundred and thirty-two patients of all ages were admitted during the study period, an admission rate of 260/100,000. Of the three hundred and forty-six adults in this group, ninety-two patients were excluded because no blood sample was taken, either because the patients refused or through an oversight. Ten further patients were excluded because they were admitted more than twelve hours after injury. The male/female ratio for the remaining two

hundred and forty-four patients was 2.4. Nearly a third of the patients were aged 12-19 years, a little over a quarter were aged 20-29 years and 10% were aged seventy years or more. Attendances peaked mid-afternoon (14-16.00 hours) and late evening (22-24.00 hours). Nearly one in five attendances were on Saturdays and only slightly less than this were on Sundays. The causes of injury were: road traffic accidents which accounted for 50% of cases, assaults 10%, home accidents 8.6%, sport 7.8%, work related accidents 4.9% and others 19%. The average duration of stay was 8.9 days. Six patients (2.5%) died.

Positive blood alcohol was found in 32% of all cases and was significantly commoner in men (41%) than women (11%). The mean blood alcohol was 214mg% in women and 228mg% in men. Positive results were also significantly more common at weekends, at night and in car drivers and front-seat passengers who did not wear seat-belts. The conscious level on admission was significantly worse in patients with positive results and coma was significantly more prolonged. No significant difference between positive and negative groups was apparent in respect of the frequency of skull fracture, intracranial haematoma or associated injuries, or in the median duration of stay. The highest proportion of positive results was found in 20-29 year olds (50%), in cases of assault (84%), domestic accidents (52%), and pedestrians (45%). Motorcycle riders had one of the lowest proportions of positive results (8%) although pillion passengers had positive results three times as often. Positive results were more common in car drivers (20%) than in front (15%) and rear-seat (13%) passengers. None of those involved in work related or sporting accidents had positive results.

These results are comparable with other studies from around the world (16, 17, 18, 25, 77, 79, 80, 81, 119, 120, 122, 135, 136). They emphasise the frequency with which alcohol is combined with head injury. Dealing with such patients, usually the task of junior staff at unsociable times, causes particular problems in accident and emergency departments. Misdiagnosis and delay in diagnosis of complications in such patients often leads to

unwarranted and unnecessary mortality and morbidity (78).

i) SOUTH AFRICA:

Rose-Innes and Le Roux (147) and De Villiers and De Villiers (148) concerned themselves with road speed restrictions and head injuries, while Roy (149) considered head injury in rugby players. Clearly these represent highly selected groups of patients, however from De Villier's (148) study we can gain some impression of incidence since he quotes local and national statistics. Thus, head injury admissions to Groote Schuur Hospital decreased by a third following the introduction of road speed restrictions in November, 1973 as did the number of serious accidents both in Cape Town and in the whole of South Africa. During the same period the number of deaths in the whole of South Africa fell from four thousand, two hundred and sixty-nine to two thousand, eight hundred and four. Most of these deaths would have been the result of a head injury. Rose-Innes and Le Roux (147) considering similar periods of time before and after the introduction of speed restrictions also showed a fall in road casualties and fatalities. These authors gave a fuller description of the head injuries treated by the accident and emergency department, hospital and neurosurgical units. The admission criteria were clearly defined and all patients fulfilling the criteria were included in the study. During the second six month period, three hundred and ninety-three patients with head injury were admitted, an increase of 11%. However the numbers due to road traffic accidents fell from one hundred and eighty to one hundred and forty-three, a decrease of a fifth, and these differences were highly significant. The authors were also able to show a significant lessening of severity of injury in the second six month period. Head injury with multiple injuries was also considerably less common in the later period. Roy (149) studied rugby injuries presenting to a single handed general practitioner during one season in 1973. Injury to the head and face accounted for one in five injuries seen. 10% of those with head and face injuries were either unconscious or suffering from concussion.

In 1970 Rune (150) reviewed the literature relating to head injury in children and conducted a retrospective community study to determine the incidence and prevalence of head injury. Patients were selected initially by the results of a questionnaire posted to the parents of all primary school children. Only severe blows to the head that had seriously worried the parents and occurring at any time in the child's life were sought. A hundred percent response to the questionnaire was eventually obtained and positive responders were interviewed over the telephone. Only four of the positive responders would not be interviewed and in these cases the initial questions revealed the injury to be unassociated with cerebral symptoms as defined. If the telephone interview revealed that the child had been knocked out at the time of injury then they were further interviewed in person. In eighteen cases (9%) this follow-up interview was not possible, in half the cases because the family had moved and in the other half because the family raised objections. No differences were apparent from the telephone interview between the 9% not followed up and the remaining children. Children living outside the city, but attending school in the city were excluded. Five thousand, one hundred and five children from a total population of about forty thousand were identified.

Seven hundred and seventy-six children had suffered a head injury as defined and 23% of these had been admitted to hospital. Four hundred and seventy-six of this larger group were adjudged to have had cerebral concussion, which was defined. Of this group one hundred and fifty-six children (33%) had been admitted, a further sub-group of two hundred and seventy-one had been knocked out at the time of injury and a hundred and one of these had been admitted (37%). In all groups there were more boys than girls and more older boys than younger ones. By cross-checking with hospital records, fifteen children were identified who had been admitted to hospital for observation following a head injury, yet did not appear as such from the questionnaire. This represents a 10-15% error in the

admitted groups. Overall the risk of head injury for boys was 17%, increasing with age, and for girls it was 13% and unrelated to age, while for head injury with concussion it was 11% and 7% respectively. Converting this to an annual risk, the percentage varied from 0.9% to 1.7% in boys for any head injury and from 0.9% to 1.4% in girls. The risk was highest for boys aged 1-6 years and for girls aged 1-3 years. The risk of cerebral concussion in boys increased to a maximum at 7-9 years (1.1%) and in girls peaked at 1-3 years (0.8%). The risk of head injury with loss of consciousness was highest for 7-16 year old boys (0.7%) and 1-3 year old girls (0.5%). Boys outnumbered girls overall by 3:2.

In those children with any kind of head injury falls of various types accounted for most injuries (80%), followed by those caused by road traffic accidents (11%). For more serious injuries involving loss of consciousness, 80% were due to falls and 13% the result of road traffic accidents, but for those with loss of consciousness who were admitted, 68% were due to falls and 28% due to road traffic accidents.

A personal assessment of the social class of all patients was made by the author although this was not related to the general population but to a randomly selected control group who had not suffered a head injury. Those with head injury who were knocked out and subsequently admitted were more often of a lower social class than those with head injury, knocked out but not admitted. The sample size was small and no firm conclusions could be made. In respect of certain sociological findings, significant differences were noted between different groups. The group of children knocked out and admitted were more often born when their mothers were under twenty-one years old than was the case in the control group of randomly selected children with no history of head injury. Similarly the mother was significantly more often unmarried, divorced or widowed and had more often worked at least half-time for at least three years during the child's pre-school life. Fathers of children in this admitted group had been significantly more often mentally ill or had been unemployed recurrently or for long

periods. Children knocked out but who were cared for at home were significantly less often born when their mothers were over thirty-four years old. The mothers of these children had significantly more often suffered mental illness during the child's life.

Regarding the children themselves, those who were knocked out and admitted were found significantly more often than the control population to suffer primary or secondary enuresis, to play truant, to be engaged in serious pilfering and to suffer serious headaches, whereas children knocked out and cared for at home were also significantly more often found to suffer primary or secondary enuresis, to be engaged in pilfering, to suffer serious headaches, to walk before they were eleven months old and to suffer from convulsions. Significance was defined as that shown at at least the 0.1 level, which is higher than the conventionally accepted level of significance. No significant differences were apparent between the groups in regard to age in speaking, handedness, all accidents, potty training, late walking or formal psychological testing. Review of social services, hospital and school dental records revealed further significant differences. The families of children who were knocked out (whether admitted or not) were significantly more often known to the social services. Children knocked out and admitted were significantly more often known to child psychiatric clinics and had been more frequently admitted for accidents or poisoning than children knocked out but cared for at home or children in the control group.

The author considered that generally unfavourable environmental conditions, mentally inadequate parents, behavioural disturbances and stress symptoms in the child characterised the population cared for in hospital and to a lesser extent those cared for at home, as compared with the control group. No evidence that these characteristics did not apply to all head-injured children was found. Largely speaking these personal and environmental factors were inter-related and these inter-relationships were demonstrated by statistical analysis. No significant differences in the children regarding clinical symptoms of brain injury were found.

k) UNITED STATES:

A large proportion of the body of work relating to head injury and its epidemiology originates from the United States. Before considering this in detail, particular attention will be paid to a paper by Barber and Webster (151) which illustrates how aberrant patient characteristics can distort the true picture. This retrospective review of head-injured patients admitted during seventy-seven months up to 30th May, 1972 had a male/female ratio of 3.8:1. No definition of head injury or admission policy was given. 22% of the one hundred and ninety-two patients identified as head-injured during the period were excluded because of the unavailability of records. The remaining one hundred and fifty who formed the basis of the study were largely Negro (one hundred and forty-seven). The age-distribution was: 19% under twenty years of age, 67% aged 20-60 years and 14% over sixty years. The largest number were aged between 31-40 years so the whole series is biased towards the older age groups compared to British studies. Of the adult patients, more than a third were widowed, separated or divorced and more than half of the working population (18-65 years) were unemployed. The majority of cases were welfare patients (65%) compared with 12% of all admissions to the same hospital. 44% were alcoholics and in 52% overall, alcohol played a significant role in causation. 13% were epileptics and were injured as a result of a convulsion, 10% experienced early epilepsy and 5% were drug addicts. There were 13% with pre-existing hypertension and a further 21% developed hypertension. Pre-existing diabetes (7%) and an abnormal glucose-tolerance in the convalescent period (5%) were also common. 10% of one hundred and one patients tested had a positive VDRL compared with less than 2% of a group of stroke and cerebral tumour patients in the same hospital. 69% were conscious on admission and mortality was highest in those with the worst conscious level on admission. 37% of the head injuries were due to blows, 33% due to falls and 14% the result of a road traffic accident. The remaining 16% had no history or physical evidence of head injury but all had a subdural haematoma.

Patients with more than one head injury diagnosis on discharge were classified according to the most serious diagnosis only. 37% of all cases had a subdural haematoma although the authors were unable to offer any explanation for the high incidence. Even assuming all forty-two patients omitted from the original one hundred and ninety-two did not have a subdural haematoma, the incidence was still very high (29%). The mortality rate was 25% (39% for operated patients and 16% for non-operated). The authors concluded that their series was similar in most respects to other published series up to that time, yet the references they quote mostly refute this conclusion. This series is obviously selected by age, race, social and economic status, predisposing factors, civil state, cause, and incidence of subdural haematoma. That this is true will be seen clearly as other American series are considered below.

Quoting national statistics based on a household survey (usually sampling 0.06% of the population), Caveness (4, 5, 6) has estimated the number of deaths in the United States due to head injury was 50,000 in 1966 (4) while the total number of head injuries rose from 7.9 million in 1970 to 1971 to 8.9 million in 1974 to 1975 (5). In 1975 the incidence was 4668/100,000 of which 44% occurred at home, 42% at play, in school or in the public domain, 12% resulted from road traffic accidents and 3% occurred at work (5). 37% of those head-injured were less than six years old, 27% were aged 6-16 years, 26% aged 17-44 years and 10% were over the age of forty-four. Of the total 1.4% had a skull fracture. In the following year there were 7.56 million head injuries, an incidence of 3589/100,000 of which 33% were under six years of age, 25% were aged 6-16 years, 29% 17-44 years and 13% were over forty-four years of age (6). 51% were injured at home, 33% at play, in school or in the public domain, 16% were the result of a road traffic accident and 3% occurred at work. During the period between 1970 and 1975, the number of minor head injuries had risen while the number of major head injuries had fallen.

In a review of acute head injuries, apart from discussing

biomechanical and pathological aspects, Gurdjian and Gurdjian (152) outlined epidemiological features which can be used as a yardstick of American studies. They suggested that of large series of head-injured patients, 30% had skull fractures, 70% of these being linear. Several recent American studies have been specifically epidemiological. Before considering these in detail, less recent studies will be discussed. As with most British papers, incidence figures can only rarely be determined from these papers.

Scott and Tweed (153) described two thousand and five consecutive patients of all ages admitted to a neurosurgical unit between 1956 and 1975. Head injury was not defined and only a brief indication of admission policy was stated i.e., the minimum requirement for admission was a history of unconsciousness. 61% of the patients had a history of unconsciousness possibly with minor symptoms but no neurological deficit and only occasionally a simple linear skull fracture. 20% had neurological signs, more than half of these had an absent response to pain with impaired or absent oculo-vestibulo-cephalic reflexes. Eleven patients (0.5%) developed a localised collection of blood of any size within the brain. Fourteen (0.7%) developed an extradural haematoma, four of these died without an operation and one was a posterior fossa haematoma. Sixty-nine (3.4%) developed a subdural haematoma during the first week. Skull fractures were present in three hundred and fifty-nine patients (18%), about half (one hundred and seventy-nine) were simple fractures. One hundred and seventy-seven were linear, only two were depressed. Half were compound fractures including eighty-four comminuted depressed fractures, twenty-eight compound linear fractures and sixty-eight basal fractures diagnosed by the presence of bleeding from any cranial orifice or by radiography. Only one hundred and ten patients (5.5%) had major extracranial injuries, usually fractured limbs, and only one patient with major head trauma was thought to have died from anything other than his head injury. Overall mortality was 9% and three quarters died within ninety-six hours. The surgical mortality was 23% varying from 29% for extradural haematoma to 41% for subdural haematoma and 55% for intracerebral haematoma. During the latter two or three

years of the study, serious brain injury increased by nearly a quarter.

Ferry and Newby (154) in a part retrospective and part prospective study identified four hundred patients with minor head injury who were admitted to an army neurosurgical unit in the years 1965 to 1970. Head injury was not defined and none of the patients selected had any other problems which would themselves require admission. Some indication of admission policy was given. Apart from the above exclusion, some other patients with minor head injury were excluded although the actual number was not stated. These results must therefore be viewed cautiously. 34% were aged 0-10 years and 27% 10-20 years. The male/female ratio was 3.7 (2.3 in those under ten and 4.6 in those over ten). The majority of children under ten were injured in falls and the commonest cause of injury in those aged 10-20 years was road traffic accidents and this applied to those over twenty years old also. Assault was another common cause in the over twenty age group. 27% of children aged 5-10 years were injured in road traffic accidents and 88% of them were cyclists, 56% were injured in falls. 3% of all patients developed convulsions (9% of those under five years). Overall 18% had amnesia and this was commonest in adults, more than a third of those over twenty being amnesic. The conscious level on admission was assessed but was presented in such a way that it is impossible to characterise the whole group. Nevertheless a little over a half were confused or lethargic on admission, one in seven had a focal neurological deficit which was commonest in patients with basal fractures or post-traumatic convulsions. As many as 10% of the whole series had a haemotympanum. 45% overall had a history of being knocked out and this became more common and also lasted longer as age increased. All patients were X-rayed and 30% had skull fractures, and these were commoner in younger patients except for basal fractures which were commoner in older patients. Nine out of four hundred patients developed intracranial haematoma, two extradural and seven subdural. Four of the nine occurred in children under ten years of age. Three developed within the first twenty-four hours (one extradural and two subdural) and six after

more than seventy-two hours (five subdural and one extradural). Three of the six with subacute haematomas had resolution of their presenting symptoms. Of those developing haematomas, convulsions, agitation, lateralising signs, confusion, lethargy and subhyaloid haemorrhages occurred more often than in the whole series, however skull fracture, unconsciousness, nausea and vomiting, headache and amnesia occurred less often.

Using data from the National Centre for Health Statistics, Kraus (26) estimated the incidence of head injury in the United States in 1974 was 3900/100,000. Deaths from head injury were not included in this figure which must therefore be an underestimate. Kraus further estimated the incidence when superficial injuries to the scalp and face were excluded as 914/100,000, although immediate and later deaths were again excluded. Kraus commented on the inadequacy of mortality figures and the difficulty of comparing different series owing to different admission policies, referral mechanisms and sources of patients. He concluded by estimating that the incidence of head injury was 4000/100,000 with about a quarter involving serious head injury. Kraus was able to identify a higher incidence of head injury in the Northern United States compared with the South. In regard to age and sex, he confirmed the preponderance of youth and also the male excess, although the sex ratio was 1.5, less than in the United Kingdom (17, 25). No definite socio-economic relationship with head injury was found although he suggested that head injury was commoner in the better educated in contrast to the United Kingdom (14, 33). He also reviewed other papers from around the world dealing with the epidemiology of head injury.

Several authors have considered head injury in sport. Blazina et al (155) for example discussed head injury in athletes and considered the use of protective head gear in American Football. Torg et al (156) discussed national statistics for head and neck injury due to American football where the patients were admitted for more than seventy-two hours. They found a lessening in the severity and incidence of head injury during the nineteen

seventies. The incidence of intracranial haemorrhage and head injury deaths in football players halved during this period. Tudor (157) reported a case of acute subdural haematoma following a blow to the head from a basketball. A novel study by Alker et al (158) described the post-mortem radiological findings in one hundred and forty-six traffic fatalities who died at the accident scene or soon after arrival at hospital. 42% had radiological evidence of head injury and two thirds of these had air in the cranial cavity, often also intravascularly. About a sixth of those with head injury also had spinal injuries whilst a seventh of the total had cervical injury alone. Corrigan (159) has discussed the alcoholic head trauma triad of fatty liver, acute pneumonia and acute subdural haematoma, commoner in the lower social classes when males outnumber females. When the triad occurs in the upper social classes, the male/female ratio is more equal. Most patients are aged 30-59 years. Accidental falls while under the influence of alcohol were the commonest cause of head injury in this group. None of these studies includes sufficient information for them to be significant in the epidemiological sense although they may be interesting in themselves.

I now propose to consider the more specifically epidemiological papers recently published from America. Annegers et al (160) reported on head injuries occurring during the years 1935 to 1974 in the Northern United States. Head injury was defined and the sources searched retrospectively to identify patients were stated. All deaths and post-mortems occurring during the study period were included. The authors reasonably maintained that all cases of head injury, except those not seeking medical attention, should have been identified. Forty thousand patients were identified on the first broad sweep and these were narrowed down to three thousand, five hundred and eighty-seven by the definition used, which approximates to that applicable to British patients admitted to general surgical wards (17, 25). For the last decade of the study the mean annual incidence rate for males was 270/100,000 and for females 116/100,000 which, if the study area and patients were representative, would produce four hundred thousand new cases

each year in the United States. Age-specific rates for males showed a marked peak (658/100,000) at age 15-24 years, while age-specific rates for women declined gradually from 0-4 years with only a minor rise in 15-24 year olds. These findings are essentially the same as those for Scottish patients admitted to primary surgical wards (19). During the whole study period, road traffic accidents accounted for 46% of head injuries, higher than the proportion for United Kingdom admissions (17, 25), but included those brought in dead and those who died in the accident department, many of which were the result of road traffic accidents. Again the rates peaked in 15-24 year olds and overall the male/female ratio was nearly 3. Falls, whether at home or elsewhere, were common in the very young and the very old and in females more than males, accounting for 19% of all head injuries. Recreation related accidents (9%) were commoner in males and peaked earlier in females (5-14 years) than in males (15-24). As in the United Kingdom, horse riding accidents were more common among girls (83) but assaults (excluding gunshot) were more common in males, peaked at 15-24 years and accounted for 4% of the total. Industrial accidents accounted for 4% of all injuries, were commoner in men and age-specific rates for men aged 15-64 years were roughly equal. Gunshot wounds accounted for 3% of the total with a male/female ratio of 12 and were commonest in older men (over forty-four years), four fifths being suicides.

A seasonal trend was apparent with a higher incidence in summer and autumn and a lower incidence in winter and spring. Cycle and motorcycle injuries were commoner in summer whereas falls were slightly commoner in winter and accidents involving car occupants were commoner in autumn and much less common in winter and spring. Fatal injuries between 1965 and 1974 numbered 35/100,000 in males and 10/100,000 in females. Severe injuries, as defined, were also commoner in males. Both mortality and serious morbidity were most often the result of road traffic accidents. In males the age-specific mortality rate increased with age with lesser peaks at twenty years and fifty years and the highest values in both sexes were in those over seventy years old. Severe injury was commoner in young males and mostly resulted from road traffic accidents. Mild

injury, as defined, was commonest in males aged 15-24 years and in females a broader but similar age peak occurred. Moderate injury in females declined gradually from a high at 0-4 years but in males remained high until about twenty-four years. In patients under the age of five, most of those with moderate injury had linear skull fractures whereas in older patients most moderate injuries were associated with prolonged loss of consciousness or post-traumatic amnesia.

During the four decades of this study incidence rates for both males and females gradually increased and most of this increase was due to an increase in mild injuries (CF.14), fatal and severe injuries changing only very little (CF.14, 19). In males most of the increase in incidence occurred among 15-24 year olds and rose from 138/100,000 in the first decade to 658/100,000 in the final decade. This was due mostly to an increase in road traffic accidents and to a lesser extent an increase in the number of assaults and injuries sustained during recreational activities. In females the age-specific incidence for ages 15-24 years increased from 48/100,000 to 182/100,000. Age-specific incidence in other age groups remained more or less static. These authors found that after sustaining one head injury the risk of having another increased and this was related to age particularly, doubling if the patient was under fourteen years old, tripling if aged 15-24 years and increasing by five times if the first injury was sustained when the patient was more than twenty-five years old.

Bowers et al (161) and Klauber et al (162) reported on head injuries in the same county of California at about the same time. The former deals with more severe injuries and will be considered later. A prospective study of all head injuries admitted to hospital or dying during 1978 was carried out and five thousand and fifty-five patients were identified (162). Head injury was defined as any injury included in ICDA (8th revision) rubrics N800, N801, N805, N806, N850-N854. This did not include patients with only lacerations or abrasions to the head (minor injuries). Gunshot wounds were also excluded. This definition is similar to that used

by Jennett (17) although the latter included more minor injuries. Nevertheless the definition used should select a population similar to a British population of head-injured patients admitted to general surgical wards. Mid-year statistics were used to determine age and sex-specific rates. The overall incidence was 295/100,000 which was very similar to that found in Britain. For females, however, the major peak in incidence occurred at age 15-19 years and paralleled the male rate overall, unlike in the United Kingdom (19) or Olmsted county (160). The expected male excess was confirmed although the male/female ratio did not rise above 2 until after the age of sixty. The overall mortality rate was 22/100,000 (32/100,000 in males and 12/100,000 in females) indicating that males suffered more severe injuries as well as more injuries overall. Case fatality rates were highest at the extremes of age. Although only 5% of 5-9 year old head-injured patients died, these accounted for 43% of all deaths for that age group and accounted for proportionally more female than male deaths. 48% of all males who died did so at the scene of their accident, 18% died in transit or in an accident and emergency room and a third died after admission (CF. 14, 21, 56, 101). For all females 36% died at the scene, 20% in transit or in accident and emergency rooms and 44% after admission. Less than 3% of those admitted alive died.

Road traffic accidents were the cause of 53% of all head injuries, 27% were the result of falls and jumps, 9% the result of fights and assaults and 4% were due to other causes. As with most other studies, bicycle injuries occurred mostly in the 5-14 year old age group, road traffic accidents were commonest in young adults and falls involved mostly the very young and elderly. More than half of all children injured in road traffic accidents were pedestrians. Motorcycle injuries occurred overwhelmingly amongst young males, assaults were also commoner in males. Road traffic accidents caused most severe injuries and accounted for 73% of all deaths and 75% of male deaths.

Most patients were injured at weekends, particularly those involved in automobile and truck accidents. May was the month with

the most head injuries and though auto and truck accidents and accidents involving vehicles and pedestrians were lower than expected in this month, all other causes were higher, particularly bicycle accidents, injuries due to motorcycle accidents and assaults. Conversely, in December and January, the months with the lowest incidence, all causes except automobile injuries were lower than expected.

In a separate publication these same authors further described a sub-group of thirteen hundred and eleven patients in greater detail (163). This selected group of patients had attended ten of the thirty hospitals covered by the prospective study referred to above. The male/female ratio was 2.0 and more children were included compared with the overall sample. Automobile injuries were under-represented (26% vs 39%) and motorcycle injuries over-represented (15% vs 7.3%) whilst other categories of road accident and other causes were of similar incidence. Age and sex specific case fatality rates were similar to the parent series. A Glasgow Coma Score of less than 8 after initial resuscitation occurred in 9% of all patients, but in 21% of vehicle versus pedestrian injuries, 16% of motorcycle injuries, 11% of auto versus truck injuries and 6% or less of cyclists and other injuries. In patients under twenty years of age, females showed a greater incidence of severe injury (i.e., coma score less than 8) than males, over this age the reverse was true. These differences between the series in regard to age and injury severity were significant. A highly significant difference was found in younger patients (0-9 years) in that less had severe injury (coma score less than 8) than did patients aged 10-19 years.

For all cases the mortality rate was 3.8%, but was 83% for patients with a coma score of 3, and 0.3% for patients with a score above 7. Within each range of scores, mortality was highly significantly correlated with increasing age but not correlated with gender. A little over two fifths of all patients had multiple injuries in the broadest sense, most often involving the limbs and lower limbs more often than upper. The mortality rate in multiply

injured patients (5.9%) was significantly higher than in patients without multiple injuries (2.3%). However when differing coma scores were allowed for, no significant differences in mortality were found between patients with and without multiple injuries. The highest mortality among head-injured patients occurred in patients with spinal injuries (57%). When coma scores were allowed for no specific extracranial sites of injury had a significantly higher mortality. Other characteristics associated with higher case fatality rates were: obstructed airway (46%), dyspnoea (40%) and shock (31%). Extremity fractures and chest fractures were also associated with a significantly higher mortality. None of these adverse factors remained a predictor of death after allowing for coma scores. Neither alcohol intoxication or prior unconsciousness were associated with higher mortality, whether in severely head-injured patients or not.

Gennarelli et al (164) have shown that independently of the Glasgow Coma Score outcome is affected by the type of intracranial lesion. They showed prognosis was directly related to both the type of lesion and the coma score. Earlier, Miller et al (165) showed that early systemic insults to the already injured brain significantly affected outcome. Separately such insults in patients with diffuse brain injury were significantly associated with a worse outcome. No significant effect on outcome in the smaller group of patients with intracranial mass lesions was found in their series, although the results suggested an adverse effect.

Bowers and Marshall (161) described two hundred consecutive cases of severe head injury, defined as a Glasgow Coma Score of 7 or less for at least six hours. During the study period, which began in January, 1978, four thousand nine hundred patients with head injury were admitted and five hundred and forty (11%) of these fulfilled the definition of severe head injury. The two hundred patients admitted to the regional trauma centre or one of the four subcentres formed the study material. The median age group for these two hundred patients was 25-29 years. The male/female ratio was 2.4. Road traffic accidents were responsible for 70% of the

cases of head injury, falls and jumps for 13%, assaults for 9%, cycle accidents for 3% and other and unknown causes for 7%.

Almost equal numbers of patients occupied each level of the coma scale from 3 to 7 with some bias to higher scores. Outcome was poorer with lower scores and the overall mortality was 36%, varying from 15% for patients with scores of 7 to 70% for patients with scores of 3. Mortality was significantly higher in the presence of a chest or abdominal injury requiring operation. The presence of a post-traumatic intracranial haematoma per se did not significantly affect mortality. However the mortality for patients with acute subdural haematoma was 52%, for patients with acute intracerebral haematoma was 33%, for acute extradural haematoma 18% and for combined haematomas 33%. Altogether fifty-six patients had 'operable' haematomas, thirty-three subdural, seventeen extradural, three intracerebral and three patients with both subdural and extradural haematomas. Haematomas were less common in the victims of road traffic accidents (only 17% of such patients had a haematoma) than in patients injured by all other means, 34% of whom suffered a haematoma. Analysis of patients in whom intracranial pressure was monitored showed a significantly better outcome in patients with scores of 3 to 5 who were monitored. However nearly one fifth of all patients were excluded from this analysis.

Patients who talked and died formed 3.5% of the total. This low proportion arose because traffic accidents, the commonest cause in this series, usually produce diffuse brain injury at the outset and less often produce intracranial haematoma which is the commonest cause of later deterioration.

Consideration will now be given to the National Head and Spinal Cord Injury Survey. A pilot study was reported by Kalsbeek and Hartwell (166). For the study proper, head injury was confined to brain injury due to external forces and requiring admission to hospital (30). Birth injuries and patients dying before arrival at hospital were excluded although the latter group were investigated in a special study (167). Only first admissions to hospital were

included. A sample of hospital discharges was selected and patients were included if their discharge diagnosis corresponded to one of several specified ICD-A rubrics (293.5, 309.2, 310.0, 311.1, 312.1, 313.1, 314.1, 315.1, 850-854). 91% of the cases of head injury had one or more of these included codes, the remainder had case finding codes only, but exhibited definite signs and symptoms within five days of injury. These symptoms were: unconsciousness, convulsions, headache, vomiting and cerebro-spinal fluid rhinorrhoea (30). The cases selected by this process would approximate to British patients admitted to primary surgical wards.

The main findings of the survey were presented by Kalsbeek et al (168) and were estimates based on a sample of twelve hundred and ten patients with head injury first treated during 1974. Terms used were clearly defined. The United States Bureau of Census mid-year population estimates for 1974 were used throughout. The relative standard error for each estimate was given so as to provide a measure of precision, higher relative standard errors indicating less precise estimates. Age was determined in two ways. For incidence rates age was defined as age last birthday at the time of admission for the counting injury, for prevalence rates age was defined as age on 31st December, 1974. These latter rates were considered to show an underestimate of about 4% based on more detailed small scale studies (167).

The overall incidence rate was estimated as 200/100,000 for head injury alone (168). Estimated age-specific rates were 230/100,000 in patients aged 0-14 years, 349/100,000 in patients aged 15-24 years, 146/100,000 in patients aged 25-44 years, 126/100,00 for patients aged 45-64 years and 136/100,00 in patients over the age of sixty-four. Rates in patients over forty-four years had a higher relative standard error (RSE). This distribution is qualitatively similar to that in the United Kingdom, although owing to definition, rates are lower. Rates were twice as high in males and slightly higher in whites (203/100,000) than in non-whites (183/100,000). For traffic accidents the rates were 98/100,000, for falls 57/100,000, and for other causes 45/100,000. The rate for

falls was the least precise of these results. Proportionately these causes accounted for 49%, 28.5% and 22.5% of injuries respectively. Causes also varied with age, traffic accidents being most common in 15-24 year olds when they accounted for 62% of head injuries. Falls were most common in children, accounting for 42% of head injuries in patients under fifteen years of age. Falls were also common in elderly patients, 43% of head injuries in patients over the age of sixty-four being the result of falls. The overall incidence rate determined by this study indicated that four hundred and twenty-two thousand new cases of head injury occurred in 1974, very close to the figure predicted by Annegers et al (160).

Broad classification of patients according to the type of head injury sustained was also attempted. Concussion (ICDA-8:850) occurred in three quarters of all patients, cerebral contusion and/or laceration (ICDA-8:851) in 6.3% and intracranial haematoma (ICDA-8:852 and 853) in 2.2%. Concussion became slightly less common as age increased, was slightly less common in males and more common as the result of a road traffic accident (79%) than as the result of falls (75%) or other causes (65%), as well as being more common in non-whites. Contusions and/or lacerations were most common in 15-24 year olds (7.7%) and least common in patients over sixty-four years of age (3.9%) and generally mirrored the age-distribution of all cases of head injury. Such injury was more common in non-whites (9.1% versus 6.3%), nearly twice as common in males (7.4% versus 4.1%) and less common in those injured in falls (5.9%) than in those injured in road traffic accidents (6.4%) or those due to other causes (6.8%). Post-traumatic intracranial haematoma became increasingly common with age, particularly in those aged over forty-four years and was six times as common in patients over the age of sixty-four as in those under the age of twenty-five. Haematomas were also more prevalent in whites and males and twice as prevalent after falls as after road traffic accidents. Estimates of concussive injuries were associated with high relative standard errors and must therefore be viewed cautiously. The tendency for traffic accidents to cause diffuse injury significantly more often than focal injury has been reported

by other authors (161, 165, 169, 170).

Temporal variations in incidence were also noted. Head injuries were most common in September and next commonest in April. A general tendency towards more cases in spring and summer and less cases in winter and autumn was noted. Daily variation in numbers peaked at weekends.

84% of patients with head injury were admitted within twenty-four hours of their injury and only 6.3% longer than forty-eight hours after. These proportions were subject to some anomalies since Day One began at midnight irrespective of the time of injury. Thus more than 84% were probably admitted within twenty-four hours of the time of their injury. 26% of patients were admitted for up to twenty-four hours, 18% for up to forty-eight hours and 11% for up to seventy-two hours. Only one in ten patients stayed longer than nine days. Length of stay tended to be shorter in younger patients and was shortest in children when the average duration of stay was 4.1 days. Average length of stay among 15-24 year olds was thirteen days but otherwise lengthened with age. The mean duration of stay in males was nearly twice that in females and was twice as long in patients injured in traffic accidents as in patients injured in any other way. Longer stay in males and in patients aged 15-24 years is easily explained by the higher incidence of road accidents in these groups. As well as causing more severe head injuries (17, 21, 29, 33), traffic accidents also produce a higher proportion of multiple injuries (25, 29, 33, 165). The hospital case fatality rate reported by this survey was 3%, although this estimate was associated with a high relative standard error. Unlike the study of MacMillan et al (25) the impact of extracranial injuries on length of stay was not investigated in the National Head and Spinal Cord Injury Survey.

The annual incidence of head injury increased each year from 1970 to 1973 with an average increase of approximately 17% per annum. In fact there was little difference in numbers between 1971 and 1972, but a large increase (31%) occurred in 1973. In 1974

total numbers decreased by 14% from the 1973 total. This decrease was due to a decrease in injuries resulting from all causes, but particularly from a decrease in non-traffic accidents.

Based on a sample of seventeen hundred and twenty-six cases of head injury the prevalence of head injury in the United States in 1974 was 439/100,000 (168). This corresponds to 926,000 cases of head injury. The prevalence is thus a little more than twice the incidence (ratio 2.2). Of these existing cases 31% were under fifteen years of age, 30% were aged 15-24 years and 7.2% were over sixty-four years old. Males accounted for 65% of the total. Road traffic accidents were the cause of injury in 53%, falls in 24% and the remainder resulted from other causes. Variation in prevalence rates generally followed the same pattern for age, sex, race and cause as did incidence rates.

This large number of head-injured patients will obviously generate considerable economic outlay. Based on a sample of five hundred and ninety-two cases of head injury, the cost of head injury was 2.4 billion dollars in 1974, equivalent to 3.9 billion dollars at 1980 prices. This is an average of 2,534 dollars per injured patient, or 4,114 dollars per injured person in 1980. The largest average annual costs occurred in patients aged 25-44 years, largely due to higher indirect costs involved in the loss of that persons productivity. Average costs were also much higher for injuries resulting from road traffic accidents and among non-whites and were slightly higher for women. All estimates of cost were associated with a high relative standard error. Direct care costs contributed approximately one third of the total for head-injured patients.

Anderson and Kalsbeek (167) highlighted some of the deficiencies of the above study. Omitting patients dying prior to arrival at hospital led to an underestimate of true incidence by about 15%, according to more detailed special mortality investigations. Likewise an underestimation of true prevalence of about 4% was revealed by life table analysis. Incorporating these findings produces a revised estimate of incidence of 230/100,000 and

of prevalence of 457/100,000 (ratio 2.0).

A further deficiency reported by these authors was the low response rate to the study questionnaire, as low as 50% in some cases. However they concluded that the effect of non-response on incidence rates was minimal compared to its effect on prevalence rates and particularly its effect on economic estimates. Variability between data collection must have been a factor, in part due to uncontrolled variation in hospital record systems, including their legibility.

Using data from the National Head and Spinal Cord Injury Survey (NHSCIS) for 1974, the Hospital Discharge Survey (HDS) for 1975 and the Health Interview Survey (HIS) for 1975, Kraus (28) was able to verify certain aspects of head injury at least qualitatively, despite different methods of selection being used. The pattern of age-specific rates was similar between the NHSCIS and the HIS, although overall incidence was three times higher in the latter study. In younger patients, however, the highest incidence in the HIS occurred in patients aged 0-14 years, whereas in the NHSCIS peak rate was in 15-24 year olds. The former study is based on household interviews and is therefore more likely to include patients with less severe injury since hospital admission is not a pre-requisite for inclusion. Furthermore, this age-specific pattern is similar to that reported for Scottish A&E attenders (19), who generally can be expected to have less severe injury. The pattern determined from the NHSCIS is similar to that for patients admitted to primary surgical wards in Scotland (19). Both studies reported a male/female ratio of about 2. The NHSCIS showed more cases occurring in spring and summer while the HIS showed no definite pattern. Prevalence rates were much lower in the HDS (169/100,000) than in the NHSCIS (439/100,000) although the patterns of age-distribution and sex incidence were about the same. Head injury for the purposes of the HDS was much narrower than for the NHSCIS, including only ICDA-8, N850-854. This could account for the difference in rates.

Despite variations in definition, admission policy etc., there seems to be worldwide agreement on several points regarding epidemiology. Jennett et al (171) and Chowdhary (172) have compared head-injured patients in various parts of the world. The latter dealt with India, Ireland, and England and Wales. Data from India consisted of three hundred and ten cases admitted in one year (1972) and no patients were excluded. The Irish data consisted of two hundred and seventy-four admissions to a neurosurgical unit (1972-1973) and has already been discussed (135), and the English data was abstracted from the Field report (14). In each instance the definition of head injury was that included in ICD (8th revision) rubrics N800-N804 and N850-N854. National population statistics were used for each country. Proportionally much higher numbers of patients were over fifty years old in England and Wales and in Ireland than in India, a point borne out by Kalyanaraman (140). In India 64% of head-injured patients were aged 0-20 years, in Ireland 53% and in England and Wales 53% while only 5% were over fifty years old in India compared with 16% in Ireland and 15% in England and Wales. The sex ratio varied from 3.7 in India and 3.9 in Ireland to 2.1 in England and Wales, reflecting different admission policies. In India only 21% of head injuries were the result of a road traffic accident compared with 40-45% in the other countries. Mortality increased with age in each country.

Comparing neurosurgical units in Los Angeles, Rotterdam and Groningen and Glasgow in regard to severe head injuries, Jennett et al (171) found that in Holland and America many more patients were admitted directly to neurosurgical wards than in the United Kingdom. The three countries were broadly similar in regard to age-distribution, cause, incidence of skull fractures, extracranial injury, intracranial haematoma and mortality.

Clearly from this review there is broad agreement on certain aspects of epidemiology throughout the world particularly concerning age, sex, cause, temporal variation and association with alcohol. As well as this, the influence of cause, age, and levels of consciousness on outcome are also generally agreed. When

differences are apparent for example in regard to the percentage of skull fractures (U.K. 7%, U.S 30%) they can usually be explained on the basis of different definitions of head injury and different admission policies. Admission policy in the United States is most likely to be responsible for the apparent fourfold increase in the number of skull fractures as compared with the United Kingdom, presumably more minor injuries being admitted in the latter than in the United States (19).

2.2 PATHOLOGY:

In the introduction to their experimental study of concussion, Denny-Brown and Ritchie Russell (173) delineated the evolution of the then widely held vascular theory of its causation. They also cited evidence that as long ago as 1705 negative post-mortem findings were reported in a case of fatal head injury. Furthermore in the nineteenth century it had been shown that glass thread buried in brain tissue could be broken by the flinging movement of the brain caused by a severe blow to the head. In their own experiments with cats, dogs and monkeys they found it much easier to produce concussion by blows to the free head than when the head was fixed. Much greater forces were required to produce concussion by crushing or penetrating injury than by acceleration. In their experiments, concussion was associated with increased blood flow through the brain and brain-stem.

In 1943 Holbourn (174), a physicist, stated that the six most important physical properties of the brain were:

- a) A uniform density about the same as water.
- b) Extreme incompressibility, again akin to water.
- c) A very small resistance to changes in shape compared with its high resistance to changes in size.
- d) A high rigidity for the skull compared with the brain.
- e) The shape of the skull and brain are important in deciding the location of injuries.
- f) Shear strains are the cause of injury.

Furthermore the properties a-e above allow the prediction of the distribution of shear-strains and therefore the location of injuries from various types of blow. He recognised two types of

injury, firstly, injury to the brain arising as a result of distortion of the skull and secondly, injury to the brain arising whether or not the skull is distorted. The first type of injury will produce focal injury of the brain subjacent to the distortion or fracture of the skull. The second type of injury results from shearing-strains due to rotational acceleration. Holbourn adduced experimental evidence and clinical observations in support of his theoretical predictions and found close agreement between them, thus implicating shear-strains as the major cause of brain injury.

In 1946 Wright (175) stated that the only way in which mechanical forces can cause a reversible block of nerve conduction is by straining nerve fibres to a critical extent. He suggested four possible results of applying force to the free stationary head.

- a) Linear acceleration of the whole skull and its contents in the line of the applied force.
- b) Angular acceleration of the whole skull and its contents about an axis within or without the cranial boundaries.
- c) Distortion of the skull with production in the rigid resilient bony structure of longitudinal and transverse waves which are highly damped by the liquid loading of the contents and surroundings.
- d) Distortion of the skull with production of a general change in pressure within it. With an ellipsoid of revolution bounded by a rigid resilient wall, reduction of the long axis results in a generalised decrease of pressure in the contents and reduction of the short axis results in a generalised increase in pressure.

He concluded that in most cases the application of force to the skull will result in a combination of these possible changes. After criticising the work of Denny-Brown and Russell and providing experimental evidence of his own, as well as considering the work of

Holbourn and Ferrari, Wright demonstrated each of his four suggested mechanisms or derived mathematical evidence of their existence. Each of the four postulated changes allowed spatial distortion of the elements of the neuraxis to occur. In the authors opinion such spatial distortion formed the mechanical basis of concussion and contusion.

Symonds (176) has pointed out that the concept of concussion as arising due to the action of acceleration or deceleration forces, adequately explains the absence of loss of consciousness in cases of severe crushing injury to the head or penetrating injury. In such cases acceleration of the head does not occur. He also concurred with Holbourn that shearing-stress was the most probable cause of superficial lacerations of the brain and of more generalised parenchymal damage. After discussing the work of various authors detailing the type and extent of brain damage, Symonds concluded that there was supporting pathological evidence for the operation of such shearing forces. This author also believed that the retrograde amnesia of concussion was the result of bilaterally symmetrical injury to the nerve fibres in the cerebral hemispheres, in some cases only the temporal lobes being damaged. Blomert and Sisler (177) maintained that retrograde amnesia was the consequence of rapid acceleration or deceleration of the brain leading to a physical alteration of neuronal axons and cell bodies. Furthermore the defect produced was selective, affecting only recent memories, and memory traces in the consolidation process at the time of injury are lost.

Symptomatic improvement from a minor concussive blow is usually complete, nevertheless repeated such injuries cause permanent sequelae as for example the punch drunk syndrome (176). This latter supports the view that any concussive blow is associated with permanent neural damage and loss of function, although such may not be demonstrated by available techniques. In older patients, intellectual changes following head injury are similar to the effects of aging itself. Presumably the functional reserves of neurones in older patients are more marginal. Similarly the

well-recognised phenomenon whereby a blow of equal severity is more likely to cause loss of consciousness the older the patient, may be a further manifestation of the marginal status of their neuronal reserve.

In 1965 Ommaya (178) presented experimental evidence of the mechanics of neural trauma, based on the Holbourn hypothesis that deformations of the brain constitute the underlying process. Although not critical for producing concussion, the site of impact was crucial for producing skull fracture. Blows to the vertex producing fracture most readily and blows to the occiput least readily, while frontal and temporal blows were intermediate. Concussion was more easily produced when the head was free than when it was fixed. In the experiments described it was impossible to produce skull fracture without also producing concussion, however, fatal concussion without accompanying skull fracture was possible to obtain. No statistically significant relationship between changes in intracranial pressure and concussion was demonstrated. Using lucite calvaria brain movements were almost identical to those predicted by Holbourn (174). Thus at impact the skull moved away and the brain lagged behind, next the brain swirled to follow the head, appearing to rotate on an axis passing through the centre of gravity of the head. Marked damping of these movements by fluid was also shown as previously suggested by Wright (175). Significantly, acute or chronic extradural haematoma or subdural haematoma over the convexity did not occur in the absence of skull fracture. Acute subdural haematoma without fracture occurred only around the base of the brain. Contre-coup injuries were rare (5%) and were related to the dural and bony projections and partitions rather than to the point of impact.

Physiological effects of concussive blows were also noted (178). An apnoeic pause was usually followed by changes in the rate and/or amplitude of respiration. In cases of fatal concussion or severe concussion associated with fracture, this pause was usually continued and the animal died in respiratory paralysis or the return of an irregular respiratory pattern presaged secondary apnoea and

death. Immediate onset of high-amplitude slow activity was seen on the electro-encephalogram in concussed animals. Primarily this occurred in the parietal areas on both sides. The amplitude of these waves soon decreased, often before the end of concussion, but the rate remained persistently slow. Occasionally a slow flat record replaced the high-amplitude activity as a later event, usually after the end of concussion. Significant changes in the rate and or pattern of the ECG also occurred viz. marked bradycardia, occasional dropped beats and extrasystoles compounding an irregular rhythm, elevated T wave complexes, increased amplitude QRS complexes, increased QT intervals and ST depression. Persistence of these changes was a bad prognostic sign. No animal died who did not have these changes immediately after impact. Only 18% of animals without concussion or skull fracture had any ECG changes compared with 55% of animals with concussion and fracture and 100% of animals with concussion and fracture who died. Concussive blows produced a fall in blood pressure lasting from half a minute to ten minutes before returning to normal, except in two animals (13%) in whom the initial fall was followed by a rise of blood pressure above that noted before concussion. Repeated sub-concussive blows produced repeated hypotensive effects until finally initial hypertension and death ensued. Initial hypertension was induced after fewer impacts by concussive blows. In severely concussed monkeys, who invariably died, immediate rise of CSF pressure occurred. In less severely injured animals a slight rise in CSF pressure was noticed several minutes following impact.

In summary Ommaya stated that the weight of available evidence indicated that cerebral concussion was not an all or none response but had several gradations from the very mild with minimal (currently detectable) sequelae to the very severe and irreversible, a view previously held by Symonds (176). Concussion can be produced both by impact directly to the head and by flexion and stretching of the neck, as in whiplash injury, which produces shear and tensile stresses in the brain-stem and other parts of the brain. Pathological damage is made up of degeneration of nerve fibres and damage to nerve cells and axons. Ommaya's results support

Holbourn's theory. The author further suggests that the looser structure of the larger brained animals, including man, allows deformation to occur more readily. Such deformation involves structures in the brain-stem, hypothalamus, cortex and upper cervical cord primarily. Secondary factors such as hypotension and hypertension, hypoxia, compression by fractured bone, oedema, blood or hydrocephalus, metabolic, enzymatic and endocrine changes, act to enhance the effect of concussion if present after head injury or to mimic it if it is absent.

Ommaya and Gennarelli (179) have discussed cerebral concussion in blunt head injuries and reviewed available clinical, experimental and pathological data. They hypothesised that the distribution of damage caused by shearing strains in blunt head injury decreased in magnitude from the surface to the centre of the brain, so that only in the more severe injuries would the deep structures of the brain-stem be involved. Therefore isolated damage to the latter structures could not occur in acceleration or deceleration injury, but must occur only in the presence of diffuse brain injury. Also, in cases of paralytic coma damage to the cortical and subcortical areas should be more severe than damage to the brain-stem. Finally acceleration or deceleration head injury followed by confusion and disturbances of memory but no loss of consciousness is possible, although the reverse cannot occur if the hypothesis is valid. Passing on to discuss the available evidence as indicated above, they found their hypothesis adequate to explain recorded observations and were unable to find any evidence to disprove it. Thus in acceleration and deceleration head injury the rotational component causes shearing stresses maximal at the periphery and the translational component produces focal injuries only.

Gennarelli, Adams and Graham (180) devised an experimental method of producing angular acceleration injuries to the head of sub-human primates. By this means the effects of impact could be eliminated, allowing the effect of acceleration to be studied in isolation. This permitted the authors to test the hypothesis that

angular acceleration is an important mechanism for producing the physiological and pathological consequences seen in closed head injury. They were able to vary the injury from that producing no concussive effect, to that producing instantaneous death. Six Grades of experimental trauma severity (ETS) were defined - Grades ETS 1-6, as well as Grade 0, in which no evidence of brain disturbance was apparent. In cases of instantaneous death (ETS 6) gross ponto-medullary lacerations occurred due to ring fractures. Deaths in ETS 5 all occurred within six hours and resulted from acute subdural haematoma due to ruptured bridging veins. ETS was highly correlated with the magnitude of the acceleration delivered and also with the presence, duration and magnitude of defined neurological and physiological abnormalities. Thus physiological dysfunction of blood pressure, heart rate and respiratory rate was more severe and lasted longer as acceleration forces were increased. Similarly loss of motor activity and alterations of consciousness were related to the acceleration force.

In an accompanying article, Adams, Graham and Gennarelli (181) discuss the neuropathological findings in the same group of monkeys. Fourteen of the fifty-three animals had a skull fracture and this finding was most common in those animals in Grades ETS 5 and 6. Subdural haematoma occurred in twenty-three monkeys, being most often found in animals of grade ETS 4 and 5. Four animals, all in grade ETS 4, had an intracerebral haematoma restricted to the frontal and temporal lobes. Cerebral contusions affecting mainly the frontal and temporal lobes were found in thirty-nine animals and were most severe in animals in grades ETS 4 and 5. Hypoxic brain damage was present in twenty-two animals, eighteen involving Ammon's horn and in the remainder involved the neocortex. Post-mortem evidence of raised intracranial pressure during life was identified in six animals. Central chromatolysis was only seen in animals allowed to survive between two and eight days after injury, when it was restricted to the motor cortex and motor nuclei in the brain-stem. This finding also only occurred in animals in grades ETS 3 and 4. After delineating these pathological findings the authors remarked on the close similarity of the brain damage

produced in their experiments to the damage observed in head injuries in man. These latter will be discussed later in this section. Interestingly, none of the animals demonstrated the feature of diffuse white matter injury as described by Adams et al (182). Although those cases with central chromatolysis were considered by the authors to have at least minimal axonal damage. Brain damage was generally more severe in animals of higher ETS grades.

Strich (183) reported extensive white matter lesions both of the hemispheres and the brain-stem in twenty cases of closed head injury. All the cases were severely head-injured and died between two days and two years after their injury. Macroscopic examination of cut brain slices revealed few lesions - mainly ventricular dilatation and tears of the corpus callosum, both present in all twenty cases. Otherwise small contusions, softening and old haemorrhage in the hemispheres and brain-stem were sometimes seen. The white matter looked normal. Microscopically there was widespread diffuse degeneration of the white matter characterised in long survivors by large numbers of fat granule cells and a decrease in normal nerve fibres. This picture was also seen in fibre bundles e.g., anterior commissure, fornix, corpus callosum and in the brain-stem tracts where it was often asymmetrical. In patients surviving only a short time, active myelin and nerve fibre degeneration occurred with large numbers of retraction balls. In all instances the cerebral cortex, apart from a few small lesions seen macroscopically, appeared normal. The histological findings identified in each case accounted for the neurological signs and mental state of the patients when alive. The author concluded that the lesions were a secondary degeneration of nerve fibres which had been stretched or torn by shear stresses and strains due to rotational acceleration of the head at the time of injury.

Freytag (184) has reported a post-mortem series of thirteen hundred and sixty-seven consecutive cases of blunt head injury, who died during the years between 1951 and 1960 in Baltimore. These represented all such cases occurring during the period irrespective

of their length of survival. Eight cases of stab wounds and two hundred and fifty cases of gunshot wounds to the head occurring during the same time were excluded, as were cases in whom old traumatic lesions in the brain were incidental findings. Only gross macroscopic findings were recorded. When death was due to several factors the single factor adjudged most significant was recorded as the cause of death.

No differences were apparent between the study group and the general population in regard to race. The male:female ratio was 4. One in ten patients were aged less than ten years, 6% were aged 10-20 years and thereafter the proportion in each decade increased slightly with age reaching 17% in patients aged 50-60 years, before falling to 13% in those aged 60-70 years and 12% in those over the age of seventy. The causes of injury were: falls (41%), road traffic accidents (43%), assaults (12%) and other (4%). More than half of the traffic deaths occurred in pedestrians and a further two fifths were vehicle occupants. Falls accounted for 41% of deaths in children under ten years of age and a further 39% of deaths in this age group were pedestrians. In patients over the age of sixty years falls accounted for a half of all deaths and a third were pedestrians. For all patients over the age of thirty, 48% of all deaths resulted from falls. Almost three fifths of drivers killed were aged 20-40 years, 35% being 20-30 years old. Passengers were also most often young, 32% were aged 20-30 years and 18% 10-20 years. All cyclists were under twenty years of age. More than half of all motorcycle riders were aged 20-30 years and 88% were aged 10-30 years. Assaults more frequently involved the middle-aged, 23% being in the 50-60 year age group and 64% in the 30-60 year age group. A history of recent alcohol consumption or a detectable blood alcohol level at post-mortem was found in 23% of all cases and 27% of cases over the age of twenty. Such evidence of alcohol intake occurred in 44% of cases over the age of twenty who died following a fall, in 21% of drivers and in 17% of adults assaulted. Slightly more than half of all cases died within twenty-four hours, a quarter survived between one and seven days, 11% between one and four weeks, 6% between one and six months and 1% longer than six

months. In the remaining 3% the survival time was unknown. Shorter survival was more common in young patients e.g., 65% of those under the age of ten died within twenty-four hours compared with 61% of 10-20 year olds, 69% of 20-30 year olds and 49% of patients over the age of sixty. A cranial operation was carried out in 38% of all cases.

Pathological findings included:

a) Skull Fractures:

These were present in 70% and were least common in children under ten years old (58%) and most common in 10-20 and 50-60 year olds (both 76%). Otherwise there was little difference in incidence between the different age groups, although 40-50 year olds had a lower incidence (63%).

b) Intracranial Haematomas:

i. Extradural Haematoma.

Two hundred and eleven cases (15%) had extradural haematomas and 4.3% of these had no contusion of the brain. A skull fracture was present in 98% and 22% of all patients with skull fracture had an extradural haematoma. In two of the four cases without a fracture the author considered that the extradural bleeding was probably caused by operation, while in the other two cases the bleeding was not space-occupying. In both these latter cases a blow to the vertex had occurred with the development of extradural bleeding subjacent to the area of injury. Only one in eight children under one year old had an extradural haematoma and two of these three cases did not have contusion of the brain. Peak incidence of extradural haematoma was in teenagers and young adults, each decade from 10-40 years showing an occurrence of approximately 23%. The incidence in other age groups was about half of this.

ii. Subdural Haematomas.

All types of subdural collection, including small effusions, were included in the definition and 63% of cases had a subdural haematoma. The subdural haematoma was accompanied by a skull fracture in seven out of every ten cases. Furthermore 63% of all cases with a skull fracture had a subdural haematoma, as did 64% of all cases without a skull fracture. Approximately one in eight cases of subdural haematoma had no contusion of the brain. All of the latter were space-occupying lesions and 79% did not have a skull fracture. The incidence of subdural haematoma was highest in children under one year (84%) and declined thereafter to a minimum in 10-20 year olds (41%) before rising again to a peak in 60-70 year olds (72%).

iii. Massive Subarachnoid Haemorrhage.

Thin-layered and clinically insignificant subarachnoid haemorrhages of venous origin were common. In 12%, however, subarachnoid haemorrhage thought likely to cause or contribute to raised intracranial pressure was present. The incidence of this type of lesion increased from 2% in patients under ten years to 18% in patients over seventy years. Such haemorrhages were usually the result of arterial bleeding caused by severe contusion of the underlying brain. In twelve cases (7.3%), five of whom had a skull fracture, the subarachnoid haemorrhage was the only traumatic intracranial lesion and was invariably basal. Eleven of these twelve cases died within one hour and in ten the subarachnoid haemorrhage was the only cause of death.

c) Primary Brain Lesions:

Contusions and/or lacerations of the brain were present in 89% of cases. They were less common in younger patients, only 44% of patients under one year old and 76% of patients under ten years, but 99% of patients aged 10-20 years and 90% of other age groups had such lesions. The cerebral cortex was most often involved and occasionally the cerebellar cortex. The majority of lesions were haemorrhagic, except in babies who had non-haemorrhagic slit-like

tears in the white matter of the gyri recti and temporal lobes. Commonly, contusions were related to bony projections and dural partitions. Lesions of the corpus callosum and basal ganglia occurred in 30% of patients with cortical contusions and 26% had lesions in the midbrain and brain-stem. The former lesions were most common in teenagers (42%) with fewer younger and older patients showing this sort of damage. A similar age-related pattern obtained in cases with lesions in the midbrain and brain-stem. Lesions of the basal ganglia, midbrain and upper pons were particularly common with frontal and vertical injuries. Medullary contusions were largely associated with fractures extending into the foramen magnum or upper two cervical vertebrae. In a few patients they were associated with blows to the vault and cerebellar herniation. Isolated contusions or lacerations occurred in about a quarter of cases with primary lesions, the remainder were complicated by the presence of secondary lesions.

d) Secondary Lesions:

These were caused by vascular compression due to generalised brain swelling or to mass effects produced by extradural and subdural haematoma and haemorrhagic contusions. Pressure effects were most often seen in the midbrain and adjacent structures and rarely in the medulla, when they were associated with traumatic cerebellar haemorrhages or severe generalised brain swelling. Secondary lesions also occurred in the cortex underlying a mass lesion or in the territory of a compressed artery, particularly in the territory of the posterior cerebral artery and its branches. 71% of all cases, including cases of immediate death, showed secondary lesions. Oedema, mostly of the midbrain and pons, occurred in 40% of all cases and haemorrhagic necrosis occurred in a further 31%. Of the latter group 80% had lesions in the midbrain and pons (and elsewhere in some cases), 15% had lesions within arterial territories only and 5% had lesions in the basal ganglia alone. Such lesions were less common in patients under thirty years, peaked in 30-50 year olds (38%) and remained high thereafter.

e) Cause Of Death:

Brain damage was directly responsible for 63% of all deaths, a further 2%, mostly cases of fracture compound via the sinuses, died of meningitis, 11% (including seven cases of cerebral fat embolism and two cases of cerebral air embolism) died from severe extracranial injuries and the remaining 24% died from diseases. Cerebral concussion was adjudged to have been responsible for 6% of all deaths. These deaths were instantaneous and no gross intra or extracranial lesions were found. A further 8% died as a result of contusions, mostly at an early stage and so did not show secondary lesions. One quarter of all deaths, including the ten deaths due to massive subarachnoid haemorrhage, were due to the effects of cerebral oedema on vital structures. Haemorrhage and necrosis causing damage to the midbrain and pons were responsible for an additional 24% of all deaths. The earliest detectable evidence of secondary midbrain damage occurred after about thirty minutes. Most of the patients who died from secondary effects survived for between several hours and a few days.

Neuropathological examination of one hundred and seventy-three patients, who died in the neurosurgical unit at Edinburgh Royal Infirmary in the five years 1962 to 1966 inclusive, have been described by Maloney and Whatmore (185). Twenty-three patients who also died in the unit during the same period were excluded either because their post-mortems were carried out by police surgeons (mostly assaults and industrial accidents) or because information on them was insufficient. During the five years of the study a further one hundred and forty cases in whom death was principally due to head injury and thirty cases where head injury was considered a secondary cause of death occurred. These latter one hundred and seventy patients also had their post-mortems carried out by police surgeons and were excluded from the study group. For the one hundred and seventy-three patients studied the male/female ratio was 3.7, 70% of females and 48% of males were over fifty years old. Causes of injury were: road traffic accidents (64%), home accidents (12%), industrial accidents (8.7%), accidents at play

(5.8%), assaults (1.1%) and others (8.1%). Allowing for the exclusion of those brought in dead, length of survival showed the same sort of distribution as that for all patients dying as a result of road traffic accidents as reported by Ruffell Smith (100), Sevitt (101), Tonge et al (125) and Simpson et al (127).

The various findings are outlined below:

a) Skull Fractures:

These occurred in one hundred and thirty-eight patients (80%) and in ninety-five of these, fractures occurred at more than one of the following sites: vault, anterior fossa, middle fossa, and posterior fossa. Such combined fractures were commoner in patients unconscious until death (61% had such fractures) than in those initially unconscious who then improved (50%), in those initially unconscious who subsequently had a fluctuating conscious level (44%) and in those not initially unconscious who subsequently deteriorated (42%). Combined skull fractures were twice as common in those with brain swelling (63%) as in those without (31%). Skull fracture of any type was found more often in patients who had survived for up to seven days (82%) than in those who survived weeks or months (70%).

b) Traumatic Intracranial Haematoma:

One hundred and twenty patients (69%) developed this complication and haematomas were multiple in 37%. The exact proportions of each type of haematoma, particularly of extradural haematoma and intracerebral haematoma are not clear from the text. Eighty-four patients (49% of all patients) had a subdural haematoma and this figure was consistent throughout. However the number of patients with extradural haematoma was either twenty or twenty-six and by subtraction the number of patients with other types of haematoma was either sixteen or ten. I have assumed that the number with extradural haematomas was twenty. Nine of this latter group also had a subdural haematoma and again this figure is consistent. These nine patients and nine others had an extradural haematoma

present at post-mortem. In a third of these eighteen patients the extradural haematoma had been missed at operation, in four cases no operation had been performed and in the remaining eight cases the haematoma had either reaccumulated or been inadequately removed. Tentorial herniation, brain-stem lesions and lateral cerebral shifts occurred in thirteen, nine and five of these eighteen cases respectively. In only three cases of extradural haematoma was the haematoma situated in the posterior fossa and in two of these cases a subdural haematoma was also present. One patient with overwhelming brain injuries died unoperated while in the remaining two patients the haematoma was missed at operation.

Subdural haematoma occurred in eighty-four patients, including nine patients who also had extradural haemorrhage. In ten cases the subdural haematoma was first recognised at post-mortem, the patients not having been operated on during life. Of the seventy-four cases operated on, the subdural haematoma had been missed at operation in a quarter, while in those fifty-six having evacuation of the haematoma reaccumulation or inadequate removal occurred in twenty-six. Altogether of fifty-four patients who had a subdural haematoma found at post-mortem, whether pure or in combination with extradural haematoma, herniation, brain-stem lesions and lateral cerebral shifts were present in thirty-six, thirty-one and twenty-seven cases respectively.

c) Minor Brain Damage:

On external examination of the brain these forty-one patients (24%) had no haematomas and no significant lacerations or contusions. Brain oedema was found in twenty-three (56%), brain-stem lesions in fourteen (34%) and minor contusion in ten (24%). Of the total of one hundred and forty-three patients operated on, 13% were considered by the surgeon to have a normal brain, obviously on only a limited inspection. Minimal brain damage occurred either in very early deaths or in long survivors. In six of the twenty long survivors a few superficial healed or healing surface contusions were present with possibly fine haemosiderin

stained scars scattered throughout the centrum semi-ovale and basal ganglia. Most often these brains were atrophic with dilated ventricles. Four of these six patients corresponded with the group of patients described by Strich (183). In those dying early and having minimal brain damage at post-mortem some had died from multiple injuries. The remainder had only a few trivial contusions, however, in the majority the brain was swollen and most of these patients were young.

d) Brain-stem Lesions:

An attempt was made to divide these eighty-three cases (48%) into primary and secondary types. The majority were obvious macroscopically and were situated in the midbrain and upper pons, rarely in the lower pons and hardly ever in the medulla. They were usually multiple, of variable size and clustered centrally in the tegmentum, or distributed linearly and antero-posteriorly in the midline. Less often they existed as a narrow zone of petechial haemorrhages on the lateral border of the midbrain involving the cerebral peduncle. Brain-stem lacerations were very rare presumably because those brought in dead were excluded from the series. Clinicopathological correlations were used to decide if lesions were primary or secondary. Thus patients unconscious throughout, dying early, with absence of brain swelling or clot, but with brain-stem haemorrhages were concluded to have primary lesions. Often these patients also had posterior fossa fractures and or contusions in the cerebellum or superior cerebellar peduncles. Conversely patients whose conscious level improved before deteriorating, who had brain swelling or intracranial haematoma and brain shifts found at post-mortem, were considered to have secondary brain-stem lesions. By these criteria about a quarter of the eighty-three patients with brain-stem lesions had primary, about a quarter had secondary and about half had unclassified lesions. The proportions of all patients with brain-stem lesions who had intracranial haematoma and contusion, skull fracture, brain swelling, herniation and minimal brain damage were 94%, 82%, 78%, 54% and 17% respectively. 61% of these patients were deeply unconscious throughout compared with only

17% who were initially conscious and subsequently deteriorated.

e) Brain Swelling:

Only 24% did not show this at a post-mortem. Patients with brain swelling were more often unconscious throughout than patients without brain swelling (69% versus 48%). Combined skull fractures and multiple haematomas were at least twice as common in patients with brain swelling. Survival was usually measured in hours or days rather than weeks or months. Lateral cerebral shifts were four times, and herniation three times as common in patients with brain swelling as in those without. Operations had been performed on 84% of patients with brain swelling and on 74% of patients without brain swelling. The incidence of contusions, lacerations and brain-stem lesions was the same whether or not brain swelling was present.

f) Contusions:

Contusions or lacerations or both occurred in 79% overall and were equally common irrespective of the trend in conscious level. 41% of the one hundred and forty-three operated cases had contusions, lacerations or brain swelling. Overall the incidence of contusions or lacerations was about the same whether brain swelling was present or not (80% versus 79%) and whether multiple injuries were present or not (79% versus 81%).

g) Multiple Injuries:

In addition to their head injuries eighty-nine patients (51%) had injuries to the limbs or other organs. Twenty-two patients (25%) had chest injury alone, twenty patients (22%) had limb injuries alone, four had abdomino-pelvic injury, two had spinal injury and forty (45%) had combinations of these injuries. Road traffic accidents accounted for three quarters of these eighty-nine patients, with pedestrians having a higher incidence of limb injuries and combined injuries, while drivers and passengers had a higher incidence of chest injuries and combined injury. Skull

fractures were present in all patients with spinal or abdomino-pelvic injury, in 85% of patients with limb injuries, in 73% of patients with combined injuries and in 70% of patients with chest injuries. Intracranial haematomas, brain swelling and cerebral contusions or lacerations were commonest in patients with chest injuries. Early death was particularly common in patients with chest injuries and patients with combined injuries. 70% of all eighty-nine patients were deeply unconscious throughout and this was most common (74%) in patients with chest injuries. No patient with multiple injuries had a normal conscious level. Spinal injuries occurred alone in two patients and in combination with other extracranial injuries in a further seven cases.

Thirty-eight consecutive patients with blunt head injury transferred to the Glasgow Regional Neurosurgical Unit who subsequently died and on whom a post-mortem was performed have been described by Graham and Adams (186). These cases were included in a larger series of one hundred and fifty-one consecutive patients dying at the Institute of Neurological Sciences in Glasgow from 1968 to 1972 (187). In the latter series all cases were secondary referrals and had sustained blunt head injury. Full neuropathological post-mortems were performed on all cases. The majority of patients had survived for more than twelve hours after their injury with a range from six hours to twenty-one months. The causes of injury were: road traffic accidents (46%), falls (43%), direct blows (9%) and crush injuries (2%). Patients' ages ranged from eight months to eighty-six years and the overall sex ratio was 4.4 with a preponderance of males.

The object of this study was to detail the occurrence, distribution and interrelationships of ischaemic brain damage. Patients with ischaemic damage restricted to contusions or to the brain-stem and of the type conventionally attributed to raised intracranial pressure were excluded. There were eleven patients in this category. A smaller sub-group of two patients showed multiple necrotic foci in the brain resulting from fulminant fat embolism. After excluding these thirteen patients the remaining one hundred

and thirty-eight cases (91%) who did have ischaemic brain damage fell into two groups - seventy (51%) showed ischaemic lesions confined to the cerebral cortex and sixty-eight (49%) showed lesions in other areas of the brain. A large part of the ischaemic brain damage identified by these authors was only evident microscopically, as loss of neurones and reactive changes (longer survivors) or neuronal necrosis with ischaemic nerve cell damage (shorter survivors).

Among those cases with ischaemic damage confined to the cortex, 47% showed ischaemic damage centred on arterial boundary zones, when it was often bilateral (82% of cases) and occurred particularly in the zone between the anterior and middle cerebral arteries. Ischaemic lesions in the lateral occipital cortex in the boundary zone between the anterior, middle and posterior cerebral arteries were less common as was damage between the middle and posterior cerebral arteries (15% of cases). A further fourteen cases (20%) showed damage within particular arterial territories, half of these involved the middle cerebral territory alone, two cases the anterior cerebral territory alone and the remaining five both the anterior and middle cerebral territories. All of the latter five cases showed bilateral involvement and in two necrosis was accentuated in arterial boundary zones. Multiple necrotic foci were present in ten further cases (14%) and accentuation in arterial boundary zones occurred in half of them. Episodes of cardiac arrest or status epilepticus were held to account for severe diffuse cortical necrosis in eight more patients (11%). In the remaining five cases (7.1%) with cortical ischaemic lesions a mixed picture of damage in boundary zones and within arterial territories occurred, bilateral in two cases. For all seventy cases damage was assessed as severe in 41%, moderately severe in 50% and mild in only 9%. Medial occipital necrosis, attributed to tentorial herniation, occurred in 43% of all cases with cortical ischaemic damage and was bilateral in fourteen of these thirty cases. For all seventy patients with cortical ischaemic damage, bilateral lesions occurred in at least thirty-seven (53%).

Sixty-six (94%) of the cases with cortical damage had hippocampal lesions, focal in 73%, hypoxic in 26% and mixed in 1%. Bilateral hippocampal lesions were present in nearly two thirds. Ischaemic lesions of the basal ganglia were found in 94%. Only 1% of these lesions were severe, 59% were moderately severe and 39% were mild. Cerebellar lesions were less common, occurring in only 56%. Most often this damage was diffuse and bilateral (64%), less often was restricted to the territories of the superior cerebellar and/or posterior inferior cerebellar arteries (23%) or was of a mixed diffuse type (8%) and least often was restricted to the boundary zones between the superior and posterior inferior cerebellar arteries (5%).

Medial occipital necrosis was present in twenty (29%) of the sixty-eight cases with ischaemic damage outside the cortex. Hippocampal lesions were present in 82% of these sixty-eight cases, focal in 89%, hypoxic in 9% and mixed in 1%. Bilateral hippocampal lesions occurred in 55%. Ischaemic damage in the basal ganglia was found in 78% of patients with damage outside the cerebral cortex. Only 1% had severe basal ganglia lesions, 34% had moderately severe lesions and 64% had mild lesions. Cerebellar lesions were less common and occurred in only 41%, diffuse in 43%, confined to arterial territories in 36% and mixed in the remainder.

For all one hundred and thirty-eight patients with ischaemic damage hippocampal lesions occurred in 88% and were significantly commoner in patients with damage confined to the cortex; basal ganglia lesions occurred in 86% overall and again were significantly commoner in patients with cortical damage, as well as being more severe; cerebellar lesions occurred in 49% of all cases with ischaemic brain damage with no significant difference between the two sub-groups. Multiple combinations of ischaemic lesions were common e.g., one hundred and twenty-two cases had hippocampal lesions, 86% of this group also had ischaemic damage in the basal ganglia and about half had cerebral cortical and half had cerebellar lesions. For the sixteen cases without damage in the hippocampus, 88% had basal ganglia, 38% had cerebellar and 25% had cerebral

cortical lesions. Similar combinations occurred in patients with basal ganglia lesions and patients with other lesions, such that overall hippocampal lesions and basal ganglia lesions were equally common, lesions in the cerebellum and cerebral cortex were much less common. For all one hundred and thirty-eight cases with ischaemic brain damage the lesions were counted as severe in 27%, moderately severe in 43% and mild in 30%. Almost one quarter of the latter group had single lesions in the basal ganglia or hippocampus.

Ischaemic brain damage was more common in patients under forty years of age (95%) than in patients over forty years (88%) but this difference was not significant. No significant relationship was found between ischaemic brain damage and partial or complete lucid intervals, associated injuries, skull fractures, intracranial haematomas, pre-existing atherosclerosis or midline shift. For the purposes of the study, hypoxic episodes were defined as occasions when the systolic blood pressure was less than 80mm Hg for at least fifteen minutes or the PaO₂ was less than 50mm Hg at some time following injury. Ischaemic brain damage was significantly more often found in patients with hypoxic episodes (97%) than in patients without hypoxic episodes (74%). Furthermore hypoxia was significantly more common in patients with ischaemic lesions confined to the cerebral cortex (91%) than in patients with ischaemic lesions outside the cortex (72%).

Utilising previously published criteria (188) the authors found that a high intracranial pressure had existed in life in one hundred and twenty-two cases (83%). The incidence of ischaemic brain damage in patients who had experienced a high intracranial pressure (97%) was significantly higher than the incidence of such damage in patients who had not suffered a high pressure during life (73%). This significant difference held for the sub-groups with ischaemic lesions in the basal ganglia or hippocampus but not for those with damage confined to the cerebral cortex or cerebellum. The authors also showed that ischaemic damage in the hippocampus and medial occipital cortex arose due to the effects of raised intracranial pressure and selective arterial compression in the

territories of the anterior choroidal, posterior cerebral and posterior inferior cerebellar arteries. These same effects caused some of the ischaemic damage in the basal ganglia and cerebellum, although this effect was inferred and not statistically proven. In the twenty-six cases without evidence of a high intracranial pressure during life, ischaemic lesions were present in the hippocampus, basal ganglia, cerebellum and cerebral cortex in not inconsiderable quantities. Thus other factors must also be involved in the formation and distribution of ischaemic lesions.

This study seems to have been particularly well conceived and the results produced should have a high degree of reliability. The discussion of the results and the authors conclusions relating to the evolution of the lesions likewise seem to be sound. They did not consider that the ischaemic lesions occurred at impact, but that they did arise within six hours of injury. Reduction in regional cerebral blood flow consequent upon a reduced cerebral perfusion pressure was believed to be the cause of focal ischaemic lesions present in half their cases. Systemic hypotension and/or raised intracranial pressure underlie this reduced cerebral perfusion pressure. Since not all cases with severe ischaemic damage could be shown by the authors to have experienced raised intracranial pressure during life, they rightly concluded that other factors must be involved. As a known hypoxic episode occurred in more than half of their cases with diffuse ischaemic lesions, hypoxia was considered to be an important and common additional factor in the pathogenesis of ischaemic damage. Hypoxia may arise as a result of reduced circulating haemoglobin (hypovolaemia), airways obstruction, chest injury, aspiration of vomitus, pulmonary oedema (due to raised intracranial pressure) pulmonary ventilation or perfusion imbalance and the effects of analgesics, sedatives and anaesthetics. In addition to hypoxia, the authors considered diffuse white matter injury of aetiological significance in the evolution of brain damage in cases without a high intracranial pressure.

The authors also discussed other causes of a raised intracranial pressure: hypercapnia, which increases intracranial

blood volume, and mass lesions, which limit the available intracranial space. We have already seen that they were able to show a significant effect of a high intracranial pressure, whereby arterial compression produces ischaemic lesions particularly in the medial occipital cortex and hippocampus. They concluded such an effect adequately explained unilateral lesions but not bilateral lesions in the middle or middle and anterior cerebral arterial territories. The work of MacPherson and Graham (189) has shown a significant correlation between ischaemic damage, especially in the middle and/or anterior cerebral arterial territories and the presence of arterial spasm or an intracranial haematoma or both. British (21, 92, 190, 191) and American series (165) have emphasised that preventable systemic insults such as hypotension, hypercapnia, hypoxia and poorly controlled convulsions are significantly associated with a poor outcome. In several British series (21, 190, 191) the commonest single preventable factor was failure in or delay in evacuating an intracranial haematoma. In the series reported by Miller et al (165) systemic insults in patients with mass lesions were associated with a worse outcome although this difference did not reach statistical significance.

Two of the same authors have reported the relationship between ventricular fluid pressure and the neuropathology of raised intracranial pressure (188). This report was based on a study of fifty-six patients whose ventricular fluid pressure had been continuously monitored during life. Forty-six patients had suffered non-missile head injury, eight had a ruptured cerebral aneurysm and the remaining two had acute meningitis without intracranial abscesses. The male/female ratio was 44:12 (3.7), the age range eighteen months to sixty-seven years and the length of survival from six hours to twenty-one months. The duration of pressure monitoring varied with the time the patient was referred and the length of time the patients survived, with a maximum of seven days. Forty-five cases had no surgical treatment or else monitoring was instituted prior to any intracranial surgery (Group A - forty-two with head injury, two with meningitis and one with a ruptured aneurysm). In eleven patients pressure monitoring was instituted immediately after

surgery (Group B - seven cases of ruptured aneurysm and four cases of head injury). Both groups were further divided into three sub-groups according to their ventricular fluid pressure - cases with pressure of less than 20mm Hg (Sub-group 1), cases with pressure 20-40mm Hg (Sub-group 2) and cases with pressure greater than 40mm Hg (Sub-group 3).

In sub-group A1 (eleven cases all head injuries) none of the cases had evidence of pressure necrosis in the parahippocampal or cingulate gyri or in the medial occipital cortex. However, one case did show macroscopic tentorial herniation. Eight of the eleven cases had sustained severe immediate impact brain damage of diffuse type. In sub-group A2 (ten cases - nine head injuries and one with meningitis), eight patients had pressure necrosis in the parahippocampal gyri, three necrosis in the cingulate gyri and six infarction in the medial occipital cortex. Only two patients had none of these features. In sub-group A3 (twenty-four cases - twenty-two with head injury, one with a ruptured aneurysm and one with meningitis), twenty-two had pressure necrosis in the parahippocampal gyri, seven necrosis in the cingulate gyri and thirteen infarction in the medial occipital cortex. One case of meningitis and one of the head-injured had none of these histological features. The latter patient showed bilateral macroscopic tentorial herniae but only survived for six hours after the injury.

In sub-group B1 (five cases - four with head injury and one with a ruptured aneurysm), four had pressure necrosis in the parahippocampal gyri, one in the cingulate gyri and two infarction in the medial occipital cortex. The patient without any of these histological findings was a case of ruptured aneurysm who had macroscopic evidence of tentorial and supracallosal herniation. Neither of the cases in sub-group B2 (both with ruptured aneurysm but no haematoma) had pressure necrosis or infarction. In sub-group B3 (four cases all with ruptured aneurysms and only 1 with a haematoma), all four patients showed parahippocampal necrosis, one showed necrosis in the cingulate gyri and two showed infarction in

the medial occipital cortex.

Following discussion of their cases and the work of others the authors justifiably concluded that the existence of significantly high intracranial pressure during life could be determined at post-mortem. Moreover, the hallmark of this raised intracranial pressure is pressure necrosis in the parahippocampal gyri either on one or both sides. Also no correlation was found between pressure necrosis in the parahippocampal gyri and hypoxic necrosis in the hippocampus, indicating that a high intracranial pressure is not an important factor in the pathogenesis of such hypoxic necrosis.

Adams et al (182) have reported their findings from a hundred and fifty-one post-mortems on head-injured patients treated at the Institute of Neurological Sciences during a five year period up to 1972. The series comprised one hundred and twenty-three males and twenty-eight females (male/female ratio of 4.4) ranging in age from eight months to eighty-six years and the length of survival varied from six hours to twenty-one months. Causes of injury were: road traffic accidents (46%), falls (43%), blows to the head (9%) and crush injuries (2%).

In twenty-six patients there was no neuropathological evidence that a significantly high intracranial pressure had occurred during life. Death was attributable to causes other than direct impact damage to the brain in sixteen cases, diffuse white matter damage had occurred in a further eight cases and two had multiple small haemorrhages throughout the cerebral hemispheres and brain-stem. Both these latter two patients had skull fractures and innumerable petechial haemorrhages in the cerebral cortex and white matter, mid-brain and pons. Skull fractures were present in fourteen of the sixteen cases without immediate impact damage. Severe hypoxic brain damage was apparent in seven cases, cardiac and or renal failure occurred in three, meningitis in two, fulminating fat embolism in one, posterior fossa haematoma in another, high cervical injury in one case and severe chest complications in the

remaining patient. Nine of the sixteen cases had talked at some time following their accident.

None of the eight patients with diffuse white matter injury talked at any time after their injury. All were unconscious from the moment of impact and remained unconscious or in the persistent vegetative state until death. Only one of these patients had a skull fracture and one had a clinically significant haematoma. All had discrete lesions in the rostral brain-stem and in the corpus callosum, as well as diffuse damage to the white matter. The brain-stem lesions occurred in the region of the superior cerebellar peduncle. In Strich's (183) paper twelve of twenty cases had lesions in one or both superior cerebellar peduncles and these were apparent macroscopically. In patients with a short survival these lesions were usually haemorrhagic and readily apparent macroscopically (182). Axonal retraction balls and rarefaction of tissue were characteristic and within a few days reactive astrocytes, hypertrophied microglia and lipid phagocytes were conspicuous. In longer survivors shrunken gliosed and often cystic lesions containing haemosiderin granules were seen. Haemorrhagic lesions in the corpus callosum were present in short survivors and microscopically, retractions balls and rarefaction were again evident. In longer survivors the corpus callosum was thin and shrunken, cystic focal lesions were present. Widespread axonal damage was evident in all eight cases, appearing as retraction balls in short-term survivors, microglial stars spread diffusely in the white matter in intermediate survivors and as degenerative changes in the white matter in long-term survivors. These latter changes were particularly noticeable in the ascending and descending tracts in the brain-stem with selective but asymmetric involvement of the cortico-spinal tracts, medial lemnisci and superior cerebellar peduncles as well as the pyramidal tracts in the spinal cord. In these cases persistent microglial stars were largely obscured by the diffuse white matter damage. Ventricular enlargement was considerable in one patient who survived for seven months, being due to the reduced bulk of the white matter and thinning of the corpus callosum.

Only two of the eight cases had cerebral contusions, three cases showed small bilateral ischaemic lesions in the boundary zones between the anterior and middle cerebral arteries. One of these latter three patients showed numerous small haemorrhagic foci in the cerebral cortex and white matter and in the right cerebral peduncle. One other of these three had two small haematomas adjacent to the thalamus. One of the cases with cerebral contusions and one other case, both showed diffuse reactive gliosis in the basis pontis.

On the basis of this series and of their earlier work relating to ischaemic brain damage (186, 187) and raised intracranial pressure (188) the authors concluded that diffuse white matter injury could occur in the absence of high intracranial pressure and in the absence of ischaemic or hypoxic brain damage. One hundred and twenty-five of the original one hundred and fifty-one post-mortems showed evidence of a significantly high intracranial pressure. Eleven had macroscopic evidence of focal lesions in the corpus callosum and rostral brain-stem. Ten of these cases had the characteristic microscopic findings of white matter injury - retraction balls, microglial stars or degeneration of fibre tracts. Contusions, haematomas and hypoxic ischaemic brain damage were more common in these eleven patients than in the eight cases with no evidence of high intracranial pressure, but in no case were these changes sufficiently extensive to cause widespread secondary damage to the white matter. None of the total of nineteen cases with diffuse white matter injury talked at any time after their accident, whereas 40% of the whole series of one hundred and fifty-one patients did talk at some time. Overall 81% of all patients had a fracture of the skull compared with 45% of those eleven cases with raised intracranial pressure and 12.5% of the eight cases with no evidence of high intracranial pressure.

In their analysis of all one hundred and fifty-one patients, no single case of isolated brain-stem damage in a patient unconscious from the moment of impact was identified. This confirms the hypothesis for cerebral concussion proposed by Ommaya and

Gennarelli (179) and referred to earlier in this section. These latter predicted that primary brain-stem damage would not occur in isolation and that when a truly primary lesion of the rostral brain-stem was found at post-mortem it should be found rarely and always in association with diffuse brain damage. These were precisely the findings in the series from Glasgow. However Turazzi and Bricolo (192) reported thirteen cases of acute pontine syndromes occurring among one thousand patients with severe head injury (comatose for twenty-four hours or more or having clinical signs of severe CNS impairment). Seven of these patients died and macroscopic and microscopic pathological study of five of these cases revealed pontine lesions in four. Three cases had no injury to the midbrain and two had no injury to the telencephalon. As well as confirming some of Ommaya and Gennarelli's postulates, this work by Adams et al (182) also tended to confirm Strich's view (183) that nerve fibres are torn by shearing strain arising at the moment of impact. The authors further concluded that many of the milder and transient forms of cerebral dysfunction due to blunt head injury arise because of failure of conduction of nerve fibres rather than to focal damage. Finally they suggested that diffuse white matter injury is the most important single factor determining the outcome in a patient who sustains a blunt head injury.

In a further publication these same authors and others describe the full range of damage occurring in fatal non-missile head injury (193). Post-mortem details of one hundred and fifty-one patients were included and the epidemiological details of these have already been given in the discussion of the last paper (182) and so will not be re-iterated. Particular note was taken of any deterioration in the conscious level after a lucid interval. The latter was defined as whether or not the patient had talked after the accident. If the patient had talked but had not been completely rational, the lucid interval was deemed partial. Thus fifty-eight (38%) of the whole series had experienced a complete (25 cases 16%) or partial (33 cases 22%) lucid interval. Brain damage was classified into three groups:

- 1) Immediate impact injury -
 - a) Contusions and lacerations
 - b) Diffuse white matter injury
 - c) Other types of diffuse brain injury
 - d) Skull fractures
- 2) Primary complications -
 - a) Intracranial haemorrhage
 - b) Brain swelling
- 3) Secondary complications
 - a) Brain damage secondary to raised ICP
 - b) Hypoxic brain damage
 - c) Infection

1a) Contusions and Lacerations:

To facilitate comparison the authors devised a contusion index based on the depth and extent of the contusion. Each of these two factors was graded from 0 (absent) to 3 (extensive). A contusion index (CI) was then derived for each anatomical site (6 defined sites on each side) and the CI's for each site were added together to produce a total contusion index (TCI). Mean contusion indices (MCI) for each anatomical site and mean total contusion indices (MTCI) were also determined. For the whole series the MTCI was 16.6. In seven of the hundred and fifty-one patients the MTCI was 0 and in thirteen further patients contusions were minimal i.e., CI was not more than 1 at any one anatomical site. Another fifteen patients had an MTCI greater than 32. MCI's were highest in the frontal (5.7) and temporal lobes (5.4) and lowest in the parietal lobe (0.7) and the cerebellum (0.9) with the Sylvian fissure (2.7) and occipital lobes (1.2) being intermediate. In thirty patients

with wholly or predominantly unilateral skull fractures the distribution of MCI's followed the same ranking as for all patients i.e., frontal highest and parietal lowest. The MCI differed little between the two sides of the brain irrespective of the side of the fracture. However MCI tended to be slightly higher on the side ipsilateral to the fracture, except for contusions related to the Sylvian fissure, the MCI being higher on the right irrespective of the side of the fracture. Sixty-seven patients had predominantly frontal (23 patients) or occipital (44 patients) fractures and the MCI was three times as high in the frontal lobes as the occipital lobes irrespective of the site of the skull fracture. Vogel (194) also reported a higher incidence of frontal contusion in such injuries. Contusions were significantly more severe in patients with a fracture of the skull and significantly less severe in patients with diffuse white matter injury (193). The MTCI was not significantly different between patients with and without a lucid interval although the MTCI in patients with a lucid interval was lower (15.1 - 58 patients) than in those without (17.5 - 93 patients). In the patients with wholly or predominantly unilateral fractures, contusions were not more severe on the side opposite the fracture. Fifteen patients had severe contusions with a MTCI greater than 32. These patients ranged in age from nine to sixty-five years and survived from less than twelve hours upto one week. Ten patients were unconscious from the moment of injury until death, three had a partial lucid interval and two a complete lucid interval. All fifteen had a skull fracture and thirteen had evidence of raised intracranial pressure. Only three had no other type of brain injury and each of the three was associated with an extensive depressed fracture.

1b) Diffuse White Matter Injury:

These nineteen patients, eight without and eleven with evidence of raised intracranial pressure have already been discussed (182). All were unconscious from the time of their injury so that none experienced a lucid interval. Skull fracture was uncommon, particularly in those eight patients without evidence of high

intracranial pressure (only one patient had a fracture) and the MTCI in this group was 3.9. In eleven patients with evidence of high intracranial pressure, five had a skull fracture and the MTCI of these eleven patients was 10.7. The lower incidence of lucid interval, skull fracture, raised intracranial pressure and generally less severe contusions (MTCI=7.8) in this group of nineteen patients compared with the remainder of the series was significant.

1c) Other Types of Diffuse Brain Injury:

This occurred in only two patients, both young adults unconscious from injury until death, which occurred within twelve hours. Both had skull fractures and multiple petechial haemorrhages throughout the cortex and white matter of the cerebrum and in the midbrain. The authors counted these as superficial in depth but very extensive so that the MTCI were 41 and 55.

1d) Skull Fracture:

One hundred and twenty (79%) of the one hundred and fifty-one patients had a skull fracture. Fifty-five of these fractures were centred on the midline of the calvaria and fourteen were restricted to the base. The remaining fifty-one patients showed fractures which were wholly or predominantly confined to one side. Thirty of this latter group had corresponding external evidence of injury. In another series of patients dying from head injury due to falls contre-coup fractures in the anterior and middle cranial fossae occurred in 12% (195). Two of these nine patients did not have skull fractures at the point of impact. Such contre-coup fractures suffer the same complications as all skull fractures in these sites.

2a) Intracranial Haemorrhage:

Only mass lesions considered large enough to cause significant compression were counted, smear subdural haematomas and subarachnoid haemorrhage were excluded. Most of these haematomas

had been evacuated prior to death. How many were first diagnosed at autopsy is not stated. Altogether ninety-seven patients (64%) had intracranial haematomas, supratentorial in eighty-eight, infratentorial in five and involving both sites in four.

Supratentorial extradural haematomas occurred in sixteen patients (11%) and ten of these had associated intradural haematomas (5 ipsilateral intracerebral haematomas, 2 ipsilateral supratentorial subdural haematomas, 1 contralateral burst temporal lobe, 1 posterior fossa subdural haematoma, 1 posterior fossa extradural haematoma and intracerebellar haematoma). One of the six patients without associated intradural lesions had bilateral extradural haematomas. Fifteen of the sixteen patients had a skull fracture in relation to the extradural haematoma. Half of all patients had a lucid interval.

Supratentorial subdural haematomas occurred in thirty patients, a third had a complete and nearly a quarter had a partial lucid interval. Skull fracture was present in 80% and this was wholly or predominantly unilateral in ten cases, five of whom had their subdural haematoma contralateral to the fracture. Five patients had associated lesions - two burst lobes contralaterally, two contralateral frontal intracerebral haematomas and one ipsilateral extradural haematoma.

Thirty-three patients had a total of forty-six discrete intracerebral haematomas, twenty-three frontal, thirteen temporal, four parietal, two occipital and four centred on the basal ganglia. A single haematoma was most common (23 patients), eight patients had two intracerebral haematomas, one had three and one had four. Five patients also had extradural haematomas and two had subdural haematomas. A partial lucid interval occurred in eight patients and a complete lucid interval in seven. A skull fracture was present in 88%.

Burst frontal lobes were found in fourteen patients, burst temporal lobes in eighteen and one patient had burst frontal and

temporal lobes. One of the thirty-three patients had an ipsilateral extradural haematoma and two patients had a contralateral subdural haematoma. Skull fractures were present in 91%. A partial lucid interval occurred in nine patients and a complete lucid interval in four. Seventeen of the patients with burst lobes had wholly or predominantly unilateral skull fractures and in nine the burst lobe was ipsilateral to the fracture and in eight was contralateral.

Nine infratentorial haematomas occurred, three intracerebellar, two subdural haematomas, two burst lobes and two extradural haematomas. Four of these also had supratentorial haematomas. Two-thirds of these nine patients had a skull fracture in the posterior fossa, always ipsilateral to the haematoma.

2b) Brain Swelling:

Localised brain swelling occurred in relation to cerebral contusions. Unilateral brain swelling was present in seventeen patients (11%), all had a skull fracture and five of the seventeen had a wholly or largely unilateral fracture. In the latter five, swelling was ipsilateral to the fracture in two and contralateral in three. The CI for the ipsilateral hemisphere was 11.8 and for the contralateral hemisphere 4.3. The association of acute subdural haematoma with unilateral brain swelling (7 out of 17 cases) was statistically significant.

Diffuse swelling of both cerebral hemispheres occurred in nine patients. Two thirds of this group were children (less than 17 years) and only a third of these had a skull fracture. A complete lucid interval occurred in one four year old child who also developed an extradural haematoma. Two further patients had a partial lucid interval. Diffuse brain damage of immediate impact type occurred in two of the six patients without a lucid interval and a third patient had multiple cortical haemorrhages. The MCI of all nine cases was 20.9 equally divided between both sides (left 10.9 - right 10.0), but for the five children aged fifteen years or less was only 11.2. In three of these latter five the contusions

were minimal, the MTCI being 0, 2 and 3.

3a) Brain Damage Secondary to High Intracranial Pressure:

Using previously determined criteria (188) the authors were able to identify at post-mortem when high intracranial pressure had existed during life. Necrosis of the parahippocampal gyri, which allows the pathologist to determine that high ICP existed in life, will not be present if an expanding infratentorial lesion was present or if the pressure was only raised for a short time. One hundred and twenty-five patients (83%) had evidence of high intracranial pressure i.e., a supratentorial expanding lesion. Most were due to intracranial haematoma or brain swelling and produced haemorrhage or infarction in the brain-stem. 96% of patients with high intracranial pressure died within four weeks.

Of the remaining twenty-six patients with no post-mortem evidence of high intracranial pressure during life, eight had diffuse white matter injury (182), seven had severe hypoxic brain damage and two had multiple haemorrhages throughout the brain. The causes of death in the remainder were cardiac and/or renal failure (3), meningitis (2), fulminant fat embolism (1), high cervical spinal injury (1) and severe chest injury (1). One patient had an isolated extradural haematoma in the posterior fossa.

3b) Hypoxic Brain Damage:

This occurred in Ammon's horn in one hundred and twenty-two patients (81%), in the basal ganglia in one hundred and nineteen (79%), in the cerebral cortex in seventy (46%) (infarction of the medial occipital cortex secondary to high ICP and tentorial herniation was excluded from this group) and in the cerebellum in sixty-seven (44%). Only thirteen patients (8.6%) had no evidence of hypoxic brain damage.

In the cerebral cortex hypoxic damage was most often (47%) centred on the boundary zones between major cerebral arterial

territories, especially between the anterior and middle cerebral territories. In 82% of this group such damage was bilateral. In a smaller group (20%) hypoxic damage was confined to the territories supplied by the anterior and/or middle cerebral arteries and was bilateral in more than a half. A further ten cases (14%) showed multiple necrotic foci throughout the cerebral cortex. Eight cases (11%) had severe diffuse cortical necrosis attributable to an episode of cardiac arrest or status epilepticus. Finally five patients (7%) had a mixed pattern of hypoxic brain damage. Damage in this group of seventy patients was severe in twenty-nine (41%), moderately severe in thirty-five (50%) and mild in six (9%).

Hypoxic brain damage was significantly more common in patients who had experienced a known clinical episode of hypoxia (systolic BP less than 80mm Hg for more than fifteen minutes or a PaO₂ of less than 50mm Hg) and in patients who had experienced a high ICP. A significant relationship also existed between arterial spasm alone, the presence of an intracranial haematoma alone or the combination of these two and hypoxic brain damage especially of arterial territory distribution in the ipsilateral cortex.

3c) Infection:

Meningitis occurred in only four patients (2.6%) and each had a basal skull fracture. In three of these cases infection was established within one week and in the fourth not until four weeks after injury.

The attention given to this paper from Glasgow is well justified by the comprehensive macroscopic and microscopic account of the pathology of head injury which it sets out. The authors emphasise how, impressive and easily seen though they may be macroscopically, skull fractures and contusions may be less important as a cause of death than severe hypoxic damage and white matter injury, which may only be seen microscopically. Thus in 13% of their series the CI indicated that the contusions found were superficial in depth and small in extent (i.e., CI less than 1) in

any one of the twelve selected sites. In three cases however, severe contusions alone appeared to be the main factors leading to death, each patient having an extensive depressed fracture. The authors believed that diffuse white matter injury was the single most important factor determining outcome after blunt head injury and that such injury occurred as the result of shearing strains in the white matter.

Diffuse brain swelling was particularly common in children, and half of these had minimal contusions. The authors stated that in children, brain swelling may be due in part to loss of vasomotor tone leading to vasodilatation. Further, persistent vasodilatation may damage or alter the blood brain barrier and lead to true vasogenic extracellular cerebral oedema. Severe hypoxic brain damage and diffuse white matter injury are further causes of diffuse brain swelling. 91% of the patients had evidence of hypoxic brain damage although this may be an overestimate for all head injury deaths, due to selection. However, as a secondary complication this damage should be preventable and its significant association with hypotension, hypoxia and raised ICP has already been mentioned. The authors argue that the distribution of the damage suggests reduction in cerebral perfusion pressure is largely responsible. The findings in this series of reports are very similar to those produced experimentally and referred to earlier (181).

Further pathological reports relating the gross macroscopic post-mortem findings in head injury deaths have been detailed in the epidemiological section (100, 101, 125, 127). Similarly brief details will appear in the sections dealing with extradural and subdural haematomas.

Apart from the gross macroscopic and microscopic findings following head injury, biochemical changes, alterations in cerebral blood flow and other changes are involved in the pathogenesis of the primary lesion. These changes have been reviewed by Bruce et al (196), Horton (197), and Gurdjian and Gurdjian (152). Horton (197) stated that following severe head injury there is widespread

neuronal damage and diffuse ischaemia leading to tissue acidosis as a result of the increased formation of lactic acid, disturbance of autoregulation, loss of carbon dioxide reactivity, inhomogeneous cerebral blood flow and reactive hyperaemia. These factors together with hypercapnia and hypertension lead to the formation and spread of cerebral oedema following which intracranial mass lesions and increasing oedema exhaust the compensating mechanisms for the control of intracranial pressure leading to a reduction in cerebral perfusion pressure or tentorial herniation. Reactive hyperaemia and intracranial pressure increases are maximal on the second to third days after injury. Secondary factors which may also be involved, include any decrease in oxygen supply to the brain (respiratory insufficiency, hypoxia, hypotension, anaemia, hypercapnia, volatile anaesthetic agents).

Lewelt et al (198) reported their experiments with cats, and concluded that concussive brain injury produced a generalised loss of autoregulation of cerebral blood flow for at least several hours following injury. Fieschi et al (199) studied regional cerebral blood flow and intraventricular pressure in a small group of twelve comatose patients. They showed a diffuse derangement of cerebral vasomotor regulation after severe head injury; only a small proportion of resting measurements (7/45) showed regional variation in cerebral blood flow. Regional cerebral blood flow responses to carbon dioxide were generally uniform only 11% showing steal or counter-steal responses. Bruce et al (196) described several types of change in cerebral blood flow. Most adults had a low cerebral blood flow following injury. In patients with diffuse injury and no focal lesion the cerebral blood flow was uniform throughout the brain. When mass lesions were present the cerebral blood flow varied from area to area often being less than half in areas of haematoma or oedema, a finding confirmed angiographically by MacPherson and Graham (189). Most adults and some children have subnormal cerebral blood flow values paralleling the degree of neurological dysfunction. If recovery ensues, cerebral blood flow increases to normal, while it continues to decrease in those patients who die. Normal or supranormal cerebral blood flow values

are most often seen in children and adolescents. These patients are hyperaemic. Cerebral blood flow returns to normal as patients recover or progressively falls in those who die.

Activated coagulation (200), disseminated intravascular coagulation (201, 202) and decreased platelet aggregation (203) have all been reported as occurring rarely and more often transiently after head injury. However these have more often been manifest as positive laboratory tests rather than clinical syndromes. Release of thromboplastins by the injured brain is thought to underlie disseminated intravascular coagulation (201) and activated coagulation (200). Vecch et al (203) suggested that decreased platelet function arises because of increased catecholamine and acetylcholine levels due to brain stem dysfunction. Disordered cyclic adenosine monophosphate metabolism has also been shown to occur (204).

Miner et al (205) have stated that disseminated intravascular coagulation following brain injury may be life threatening, may occur without overwhelming brain injury, may affect multiple organs and may have long term sequelae. They studied eighty-seven consecutive head-injured children on a prospective basis. These represented a little over 60% of children with head injuries admitted to their major trauma centre each year. All the children were evaluated by clinical examination, CT scan and clotting studies within two hours of injury. Types and severity of injury were defined. Disseminated intravascular coagulation was considered present if three or more coagulation tests were abnormal. The children ranged in age from 2-18 years with a mean age of eleven years and the male/female ratio was 2.1. Severe head injury occurred in thirty-seven patients (43%), moderate injury in twenty-nine patients (33%) and mild injury in twenty-one patients (24%). Penetrating injuries occurred in twenty patients (23%), mass lesions in fourteen (16%) and diffuse brain injury in fifty-three (61%). Extracranial injuries were present in 59%.

The proportion of patients with any one abnormal clotting

study increased with the severity of injury, thus 87% of severe cases, 72% of moderate cases and 52% of mild cases had such an abnormality. The same was true of the type of injury, those patients with more destruction of brain tissue having the highest proportion of abnormal results - penetrating injuries (86%), mass lesions (75%) and diffuse brain injury (58%). Overall 71% of all patients had a least one abnormal test result, most commonly an increase in the concentration of fibrin degradation products and least often a decrease in platelet numbers. Disseminated intravascular coagulation, as defined, was present in 32% of patients and was related to the severity and type of injury as well as to the mortality. Abnormalities of coagulation and disseminated intravascular coagulation were no higher in children with extracranial injuries than in children without such injuries. Death occurred more than four times as often in patients with disseminated intravascular coagulation, for penetrating injuries it was seven times higher in patients with disseminated intravascular coagulation and for patients with severe injury and disseminated intravascular coagulation it was 2.5 times that in patients with severe injury alone. No patients with mild injury had disseminated intravascular coagulation and none died. Patients who survived showed only a transient abnormality in their clotting studies unless another event occurred. Many of those who died did so after their coagulation studies had returned to normal and did not have massive haemorrhage or intravascular clots at post-mortem. The authors suggested that death may have resulted from diffuse microvascular occlusions causing increased brain damage and multiple organ failure. Alternatively they suggested clotting abnormalities might be an epiphenomenon merely reflecting the severity of the brain damage.

A recent leading article has reviewed the relationship between disseminated intravascular coagulation and head injury (206). Post-mortem evidence of fibrin deposition and ante-mortem renal failure were recognised as occurring. The author concluded that when disseminated intravascular coagulation was present appropriate treatment was definitely warranted since this may lead to the survival of some patients with substantial parenchymal injury.

A direct relationship between the concentration of serum lactate dehydrogenase and severity of head injury has been shown by Rao et al (207) in a series of one hundred and ten head-injured patients with no extracranial injury. Serum lactate dehydrogenase was high in patients with intracranial haematoma, those unconscious for more than one hour or with post-traumatic amnesia for more than twenty-four hours and those with brain-stem injury, and low in patients unconscious for less than one hour or with post-traumatic amnesia for upto twenty-four hours as well as in patients with concussion. There was also a gradation in lactate dehydrogenase levels on day one with patients who ultimately died or were severely disabled having the highest levels. This relationship to ultimate outcome was consistent at each subsequent time period falling to normal levels in good quality survivors and those moderately disabled but remaining elevated in those severely disabled. When extracranial injury existed, then lactate dehydrogenase isoenzymes could be measured instead of total lactate dehydrogenase. This enzyme is released from damaged brain and is also elevated in cases of CVA and cerebral tumour. Brain isoenzyme of creatine kinase is also significantly elevated compared to controls, sometimes within thirty minutes of head injury (208). In patients who died, the level remained high for several days while in less severely injured patients it returned to normal within two to three days. Levels were more likely to be high when cerebral contusion, laceration or swelling occurred (100%) and less likely in patients with concussion alone (63%). Raised levels also occur in dementia and cerebellar degeneration.

A more recent study by Bakay and Ward (209) has also investigated serum and cerebro-spinal fluid enzyme changes after neurotrauma. They studied changes in the total enzymes and brain isoenzymes of creatine phosphokinase (CPK), lactate dehydrogenase (LDH) and glutamic oxaloacetic transaminase (GOT) following blunt head injury in one hundred and thirty-nine patients. Similar studies were undertaken in small groups of patients with spinal cord injury, gunshot wounds to the head, pseudotumour cerebri, posterior fossa tumours and herniation, and hysterical paralysis. A control

group of twenty-five patients with no neurological pathology was also studied. The main study group had a mean age of thirty-two years with three fifths of the patients aged 20-40 years and only two patients (1.4%) were under ten years of age. The male/female ratio was 3.8. Causes of injury were: road traffic accidents (74%), falls (14%), assaults (5.8%) and other (5.8%). Slightly more than a third of patients had a major injury to two or more organ systems.

Mean serum levels of the brain isoenzymes of CPK and LDH were significantly correlated with the conscious level as measured by the Glasgow Coma Scale. The incidence of multiple injury was also correlated with the coma score and the mean serum levels of all enzymes were always higher in patients with multiple injuries than in patients with head injury alone. However, no significant correlation was found when comparing the presence of the brain isoenzymes of CPK in patients with multiple injuries and in patients with head injury only. In a separate group of fifty multiply-injured patients who did not have neurological injury, CPK brain isoenzyme was only detected in two patients. Only the presence of the brain isoenzymes of CPK and LDH in serum correlated with coma scores in the range 3-7. Multiple injury did not correlate with scores in this range. Furthermore only the brain isoenzyme of CPK was present significantly more often in patients who died than in patients who survived.

Mean cerebro-spinal fluid levels of total CPK, brain isoenzymes of CPK, total LDH and LDH isoenzymes, and protein were all significantly correlated with the Glasgow Coma Score. However for patients with scores below 8 only the levels of the isoenzymes of CPK and LDH were directly correlated with the coma scores. Similarly only these enzymes were significantly correlated with outcome, levels being significantly higher in patients who died or became vegetative than in patients who had a better outcome.

Greatly elevated levels of CSF isoenzymes of CPK were found in patients with gunshot wounds to the head but not in patients with pseudotumour cerebri, spinal cord injury, posterior fossa masses or

hysterical paralysis, although small increases of less than 20 iu/litre did occur in some cases, usually when herniation was present. CSF CPK isoenzyme activity was also detected in patients with coma scores of 15 who had depressed skull fractures or proven cortical lacerations but not in patients with scores of 15 who were unconscious for upto ten minutes, had no focal neurological deficit and no convulsions.

Patterns of change in enzyme levels during the first seventy-two hours were not significantly different between survivors and non-survivors. The highest CPK isoenzyme levels occurred on admission or peaked between twelve and twenty-four hours later and then decayed over the ensuing seventy-two hours. Dexamethasone did not affect either the level of enzymes or the relationship between levels and coma score or levels and outcome. Anoxic as opposed to mechanical brain injury caused a delay in measureable elevation of CPK isoenzymes in the cerebro-spinal fluid, such that the optimal time for sampling was twenty-four to forty-eight hours after injury, whereas elevation following mechanical injury was more immediate and varied with the degree of injury. The authors suggested that this was due to the persistence of intact membrane barriers in anoxic injury but not in mechanical injury. Late elevation of these levels was associated with a 90% mortality. Such increases also occurred in patients who showed late development of plateau waves in intracranial pressure, delayed haemorrhage or infarction.

No cases of elevated serum CPK isoenzymes and undetectable cerebro-spinal fluid CPK isoenzyme activity were found. In sixty-one cases no detectable serum or cerebro-spinal fluid CPK isoenzyme activity was present. In fifty-two cases measureable levels were detected simultaneously in both serum and cerebro-spinal fluid, while in forty-four cases detectable cerebro-spinal fluid levels were present when no serum activity was measureable. Cerebro-spinal fluid levels were thus a significantly more sensitive measure of neurotrauma than serum levels.

2.3 EXTRADURAL HAEMATOMA:

Conventionally, extradural haemorrhage following a blow to the head is considered to result from arterial bleeding caused by damage to the vessels by a fracture at the site of injury (210, 211, 212, 213, 214, 215). Generally such bleeding follows direct injury of the closed type (212, 216) and rarely occurs as a result of birth injury (212, 217). In their experiments with dogs, Ford and McLaurin (210) showed that a net constant force of 85gm was necessary to cause stripping of the dura. However, when a pulsatile force, such as that provided by an artery, was applied, only 35-70gm was sufficient to cause detachment of the dura from the dogs skull. They further showed that extradural bleeding of venous origin could not occur if the intradural pressure was normal. The length of time for which the force was applied was not critical, most lesions reaching their maximum size within a few minutes of injury. Subsequent neurological deterioration resulted from uncal herniation and mesencephalic distortion which occurred gradually by moulding. However, clot volume was critical. When the volume of the clot was greater than or equal to one fifth of the supratentorial volume, mortality was 100%. When this critical volume was exceeded, length of survival was longer in dogs with more anteriorly placed lesions. Smaller clots were not invariably fatal. If dural lacerations occurred at the moment of injury extradural bleeding leaked into the subdural space and an extradural haematoma did not occur, instead an acute subdural haematoma formed. These authors also noted individual variations in their animals, particularly regarding the adherence of the dura. In individual dogs, adherence was greatest at the cranial sutures and away from the temporal area.

Spontaneous extradural haematomas may also occur. Maheshwari et al (218) reported a case of an extensive convexity extradural haematoma found at post-mortem in an eighty-two year old man who had died three weeks after admission to hospital for treatment of diabetic gangrene. There was no history of head injury nor was there radiological or post-mortem evidence of skull fracture. No cerebral contusion, scalp or subgaleal damage was

evident. The patient had not received anticoagulants, no dural laceration or vascular malformation was present and the leptomeninges were normal. Histologically the haematoma was 4-7 days old. The authors concluded that the haematoma had occurred spontaneously, although they were unable to deny the possibility of minimal trauma. One year later, Sanchis et al (219) described two cases of spontaneous extradural haematoma, one associated with a Berry aneurysm of the middle meningeal artery and a small parietal dural aneurysm and the other associated with a middle ear infection. They also discussed a third mechanism by which spontaneous extradural haematoma could occur, i.e., secondary to coagulation defects either spontaneous or acquired. However they were unable to identify a single case of this type when surveying the world literature. Recently Findler et al (220) recorded two cases of post-traumatic extradural haematoma occurring in children, one of whom had severe haemophilia, whereas the other had Factor V deficiency. A case of extradural haematoma due to rupture of a post-traumatic pseudoaneurysm of the middle meningeal artery was reported by Garza-Mercado and Campa (221). This aneurysm lay beneath a linear temporo-parietal fracture and was demonstrated pre-operatively by angiography. This case was the fifteenth reported in the world literature at that time. The previous fourteen had all had a subacute course, usually of 7-10 days, but as long as one month. However in the case reported by Garza-Mercado and Campa, the injury had occurred only twenty hours earlier when the patient was struck by a car. When admitted to the referring hospital shortly after the accident he exhibited a motor aphasia and contralateral hemiparesis. Operation was performed three days after injury, following neurological deterioration when a carotid angiogram revealed an extradural haematoma and middle meningeal aneurysm. Full neurological recovery followed successful operation.

Marks and Shaw (222) have also recently described a case of spontaneous extradural haemorrhage. Their patient had no evidence of coagulopathy, dural vascular malformation or arteritis. Bleeding in this case was thought to have occurred as a result of infarction of a granulomatous polyp due to entrapment in a bony defect of the

posterior wall of the frontal sinus. This bony defect was caused by erosion by granulomatous tissue.

Most commonly, and classically, extradural haematoma occurs in the temporal area (212, 216, 223, 229), and rarely in the posterior fossa (216, 223-235). Anterior fossa extradural haematomas are also uncommon (211, 216, 225-228). Four cases of subfrontal extradural haematoma, each with a subacute course and ipsilateral exophthalmos, have been described (236, 237). A case of subacute bifrontal extradural haematoma was reported by Rockett et al (238). Bilateral lesions are also uncommon but have been described by several authors (213, 239, 240, 241).

Although less well documented than in the case of subdural haematoma, acute, subacute and chronic forms of extradural haemorrhage occur. Tawfik (242) described four cases of subacute extradural haematoma. These cases represented 0.4% of all admissions for head injury and were relatively benign. Three were situated parietally and the other was frontal. The subacute cases already referred to above and reported by Gruszkiewicz (236, 237) and Rockett et al (238) were situated in the frontal region. Iwakuma and Brunngraber (243) described twenty-one cases of chronic extradural haematoma i.e., cases operated on more than thirteen days after injury, the longest interval being forty-one days. These cases accounted for nearly one third of patients with extradural haematoma operated on during a twenty year period, although many were secondary referrals. A skull fracture or diastasis was present on X-ray (14 patients) or at operation (6 patients) in 95% (20 patients). Two of the patients had a false aneurysm of the middle meningeal artery and in the same number, the haematoma was encapsulated. Overall the incidence was higher in patients under forty years of age. Microscopic but not radiological evidence of ossification occurred in five patients, four of whom were less than thirteen years old. The source of bleeding was probably venous in fourteen patients and arterial in five.

Dharker and Dharker (244) reported a case of extradural

haematoma with a localised pulsatile fronto-temporal swelling. This swelling first became noticeable four months after the patient, a seven year old boy, had fallen about 10 feet, with resulting loss of consciousness for thirty minutes. In the interim the patient was entirely well. At presentation, six months after the injury, the swelling was 8cm in diameter, early bilateral papilloedema was present and skull X-ray revealed suture diastasis with a 3.5cm bony defect in the frontal area. Operation revealed a thick clot under the scalp communicating via the defect with an extradural haematoma, no capsule was present. Decompression of the extradural haematoma via a fracture thus causing the swelling was thought possible. A similar mechanism occurred in four of six children with chronic extradural haematoma described by Iwakuma and Brunngraber (243). Each of these children had a large subgaleal haematoma communicating with an extradural haematoma via a fracture line.

Extradural ossification following an extradural haematoma occurred in a young male epileptic described by Iwakuma and Brunngraber (245). This patient was operated on nearly eleven weeks after sustaining a head injury with linear skull fracture. At operation an encapsulated frontal extradural haematoma was disclosed beneath the fracture. Curvilinear calcification was present between the dura and the haematoma. The outer layer of the dura normally forms the periosteum of the inner surface of the skull and this was thought to account for the occurrence of calcification. The first reported case of post-traumatic extradural hygroma has recently been described (246). The patient, a two year old boy, fell about five feet from a slide and landed on the back of his head and shoulders resulting in immediate loss of consciousness. Less than half an hour after injury, examination revealed an unconscious child with spontaneous limb movements, pupils were equal and reactive, a small occipital haematoma was present and neck movements were resisted. Consciousness was regained during the ensuing few hours and progressive improvement continued until three days after injury. At that time he was noted to hold his neck in extension and by the next day bilateral lower motor neurone facial paresis, bilateral blunting of corneal reflexes, regurgitation of food, choking,

bilateral hypalgesia of the limbs and trunk and marked retrocollis were present. Conscious level and pupillary reaction remained unchanged. No fracture was present on skull X-ray. However, on CT scan an occipital fracture extending into the foramen magnum and an extradural posterior fossa lesion were present. At operation this lesion was revealed to be a collection of clear fluid under pressure with a volume greater than 100mls and associated with an extradural blood clot of about 30mls. Bleeding was from an emissary vein, also a small tear was present in the dura of the cisterna magna with cerebro-spinal fluid leaking through it. Needle aspiration of 80 mls of clear fluid from beneath the operation wound on the fifth post-operative day was undertaken when the child began vomiting and showed neck stiffness. Similar aspirations were required on the eighth and twelfth post-operative days and full recovery followed.

2.3.1 INCIDENCE:

Jamieson (247) has pointed out that in Brisbane there has been a trend away from local remediable injuries towards multifocal brain damage. The ratio of uncomplicated extradural haematoma to subdural haematoma found at post-mortem altered from 3:1 in 1935 to 1:30 in 1963. Jamieson attributed the major part of this change to an increase in severe acceleration - deceleration injury caused for the most part by road traffic accidents. If this trend is a worldwide phenomenon, which would seem likely, its effect must be allowed for when interpreting the incidence figures now to be discussed.

McKissock et al (228) presented a series of one hundred and twenty-five cases of extradural haematoma occurring during a twenty year period. All were secondary referrals so that although the cases represented 3% of all head injury admissions during the same period, this is likely to be a considerable over-estimate of the true incidence. In Oxford between 1948 and 1953 2.6% of head injury admissions developed extradural haematomas (43). Covering part of the same period as McKissock, although reporting on experience in Australia, Hooper (212) reported a personal series of eighty-three

cases treated during the years 1947 to 1958. However, he gave no information regarding the number of head injury admissions during the same period. In another communication he estimated the incidence of extradural haematoma as 2% of head injury admissions (235). Neither Gallagher and Browder (211) nor Mendelow et al (233) furnish sufficient information to permit incidence to be determined. From the latter paper, however, we can recognise that the number of pure supratentorial extradural haematomas doubled between 1951 and 1960 (27 cases) and 1968 and 1977 (56 cases). In Brisbane between 1956 and 1967 extradural haematomas occurred in 1.5% of head injury admissions (225). In India between 1958 and 1971 1.1% of head injury admissions developed an extradural haematoma (216) while in Finland between 1967 and 1971 it was 4.6% (248). Between 1961 and 1973 in Amsterdam 3% of head-injured patients developed an extradural haematoma (249). For the years 1964 to 1975 in Oslo 1.4% of nine thousand six hundred head injury admissions developed acute extradural haematomas (226). In the seven years upto June, 1978 in Thailand 2.8% of head injury admissions developed extradural haemorrhage (229) and during a similar period in Spain 2.7% of admissions developed this complication (224).

Of necessity most of these reports originate from neurosurgical centres and are biased by virtue of including secondary referrals. Furthermore some authors included only acute cases (233) or operated cases (225) whereas others included all patients (211, 212, 216, 226, 227, 228, 229, 248, 249). Nevertheless there seems to be reasonably close agreement, such that the incidence as determined from the above studies was 1.1% - 4.6% with only one series greater than 3%. If all cases of extradural haematoma occurring in the catchment area of the Spanish series attended the hospital in which the authors worked, then the incidence was 0.7/100,000 per annum (224).

A more realistic estimate of the current incidence in Britain is provided by Galbraith (250) who reported that extradural haematoma occurred in 0.2% of head injury admissions. This figure

was also the reported incidence in Mersey Region in 1975 to 1976 if one assumes all patients with extradural haematoma were referred to the Regional Neurosurgical Unit (56). Again making this latter assumption the incidence in the catchment area of the Glasgow Regional Neurosurgical Unit in 1974 to 1975 was 1.1/100,000 per annum and in Aberdeen was 0.8/100,000 per annum (29). However in Mersey Region during 1975 and 1976 it was 0.5/100,000 per year (56).

The incidence among patients submitted to CT Scan is higher, thus Dublin et al (251) reported 2.5% of two hundred patients had extradural haematoma. Sweet et al (252) recorded extradural haematoma in 3.6% of their series of severely head-injured patients and Bruce et al (196) found 4.4% of three hundred and seventeen patients had an extradural haematoma. In the childrens series to be discussed, the incidence varied from 0.9% (134) to about 3% (253) of head injury admissions with most reporting an incidence of 2-3% (223, 253, 254).

2.3.2 AGE AND SEX:

The general pattern of an excess of males among head-injured patients also occurs in patients of all ages with extradural haematoma (211, 216, 224, 225, 226, 228, 229, 249, 255) and in children (223, 253, 254, 256). The male preponderance, however, is more exaggerated than in all head injury admissions varying from a ratio of 3.4 (226) to a ratio of 14.2 (211). In infants under two years old the ratio was 1.1 (257) and in other children varied from 2.3 (254) to 3.8 (253).

The age-distribution of the series described is shown in Table 2.10 and of children in Table 2.11, peak incidence occurs in the second and third decades. In McKissock's series (228) 22% were under fifteen years and in Hoopers series (212) 25% were under fifteen years, whereas Heiskanen (248) reported a lower figure of 19% under seventeen years and Phonprasert et al (229) the similar figure of 22%. In children, incidence increases with age (223, 253, 256) with a peak at 6-10 years (212), although the results of

AUTHOR & YEAR STUDIED	AGE RANGE & No. OF PATIENTS	AGE				
		0-10	10-20	20-30	30-60	60 +
McKISSOCK ET AL 1941-1959	ALL AGES 125	14%	26%	23%	34%	3%
HOOPER 1947-1958	ALL AGES 83	17%	15%	24%	37%	7%
GALLAGHER + BROWDER 1935-1960	3-75 YEARS 167	8%	13%	38% (20-40) YEARS	32% (40-60) YEARS	9%
McLAURIN + FORD 1951-1962	ALL AGES 47		34% (0-20) YEARS	30% (20-40) YEARS	32% (40-60) YEARS	4%
JAMIESON + YELLAND 1956-1967	9/12 - 84 YEARS 167	13%	31%	18%	34%	4%
RAO ET AL 1958-1971	ALL AGES 96	7%	18%	39%	35%	1%
JONKER + OOSTERHUIS 1961-1973	ALL AGES 100	11%	19%	23%	31% (30-49) YEARS	16% (50+) YEARS
KVARNES + TRUMPY 1964-1975	ALL AGES 132	9%	14%	10%	50%	17%
HEISKANEN 1967-1971	ALL AGES 80		20% (0-16)	48% (17-39)	29% (40-59)	4%
PHONPRASERT ET AL 1971-1978	3-71 YEARS 138	11%	36%	28%	23%	2%
CORDOBES ET AL 1973-1980	ALL AGES 82	9%	19%	22%	39%	11%

Table 2.10 Age-distribution of extradural haematoma.

Ingraham et al (254) do not conform to this pattern. No apparent reason exists for this non-conformity. All authors agree that extradural haematoma is uncommon over the age of sixty years.

AUTHOR & YEAR STUDIED	AGE RANGE & No. OF PATIENTS	AGE			
		0-2	2-12	13-15	16 +
INGRAHAM ET AL ?1948	0-12 YEARS 20	55%	45%		
HAWKES + OGLE 1946-1961	3/12-18 YEARS 16	13%	31%	19%	38%
CARCASSONE ET AL 1960-1975	0-2 YEARS 19	100%			
CHOUX ET AL 1962-1974?	4/12-15 YEARS 104	16%	53%	31%	
MAZZA ET AL 1966-1980	0-15 YEARS 62	13%	35%	52%	

Table 2.11 Age-distribution of extradural haematoma in children

2.3.3 PREDISPOSITIONS AND ASSOCIATIONS:

Hooper (212) has pointed out the association between alcohol and head injury complicated by extradural haematoma and that this combination was common in the middle age group. In another series, alcohol was a factor in at least a third of patients (211). These latter authors maintained that patients under the influence of alcohol were more often rendered unconscious by less severe blows and remained stuporous for longer, making assessment more difficult. McLaurin and Ford (227) suggested that alcohol consumption in the older age groups was one of the factors implicated in the higher mortality in these patients since neurological deterioration was more difficult to recognise. Jamieson and Yelland (225) and Kvarnes and Trumpy (226) also emphasised the common association with alcohol

particularly in men. Pre-existing epilepsy and other predispositions as noted in the epidemiological section have not been mentioned in series of patients with extradural haematoma.

2.3.4 CAUSES:

It is perhaps appropriate to begin this section by reiterating the causes of head injury among admitted patients of all ages. SHIMS (17) reported the causes as: road traffic accidents 34%, falls 15%, sport 14%, assaults 12%, industrial accidents 5%, and others 20%. Against this yardstick we can compare the causes of head injury in patients who develop extradural haematoma and these are tabulated below (Tables 2.12 + 2.13). In keeping with their propensity to cause more serious injury, the commonest single cause of injury in all patients with extradural haematoma is road traffic accidents, varying from 19% (211) to 67% (224). McKissock et al (228) found pedestrians, cyclists and motorcyclists to account for equal numbers of patients and for about two to three times as many cases as vehicle occupants. Since the former group arise from proportionately fewer cases, their higher incidence compared to vehicle occupants reflects the difference in the biomechanics of the injuries. The rather low incidence of traffic accidents (19%) in the series described by Gallagher and Browder (211) was accompanied by a high proportion in whom the cause was unknown (39%). However in the text, many of these patients were stated to have been struck by a vehicle or assaulted. Phonprasert et al (229) recorded a distribution of traffic accident victims similar to that of McKissock et al (228). Thus motorcyclists accounted for 43%, pedestrians for 30% and vehicle occupants for only 19% of cases due to traffic accidents in the former group. The remaining 8% had fallen from a bus. Contrarily, Cordobes et al (224) found the breakdown of causes in traffic accident victims to be the reverse of that found by McKissock and Phonprasert, i.e., 82% were vehicle occupants and 18% were pedestrians, no cyclists or motorcyclists were observed in the Spanish series. There seems to be no apparent explanation for this reverse from a consideration of the three

papers. The paper from Spain has the highest incidence of road traffic accidents (67%) among the series discussed, yet in a seven

AUTHOR & YEAR STUDIED	No. OF PATIENTS AND AGE RANGE	RTA	WORK	FALL	ASSAULT	DIRECT BLOW	OTHER/ UNKNOWN
McKISSOCK ET AL 1941-1959	125 ALL AGES	44%		28%		13%	14%
HOOPER 1947-1958	83 ALL AGES	39%		35%		16%	10%
GALLAGHER + BROWDER 1935-1960	167 3-75 YEARS	19%		29%		13%	39%
JAMIESON + YELLAND 1956-1967	167 9/12-84 YEARS	46%					
JONKER + OOSTERHUIS 1961-1973	100 ALL AGES	63%					
KVARNES + TRUMPY 1964-1975	132 ALL AGES	35%		54%		11%	
HEISKANEN 1967-1971	80 ALL AGES	30%	4%	45%	19%		2%
PHONPRASERT ET AL 1971-1978	138 3-71 YEARS	54%		26%		17%	3%
CORDOBES ET AL 1973-1980	82 ALL AGES	67%		15%		18%	

Table 2.12 Causes of injury in patients with extradural haematomas.

year period no cases of extradural haematoma occurred in patients injured as cyclists or motorcyclists, which seems surprising.

As with head injuries in general, causes varied with age and sex. In children up to two years of age, virtually all extradural lesions occurred in patients injured in falls (257) whereas in series covering children of all ages, upto 50% resulted from falls (253) compared to a third in most series covering all age groups (211, 224, 228, 229). Jamieson and Yelland (225) reported falls were the commonest cause in their subgroup of children. The same authors found assaults and industrial accidents accounted for fewer cases in women, whilst traffic accidents, sports injuries and domestic accidents accounted for relatively more cases in women than in men. Also, domestic accidents became commoner as age increased and traffic accidents were most common in the second and third decades.

AUTHOR & YEAR STUDIED	No. OF PATIENTS AND AGE RANGE	RTA	FALL	DIRECT BLOW	OTHER/ UNKNOWN
HAWKES + OGLE 1946-1961	16 3/12-18 YEARS	38%	31%	13%	19%
CARCASSONE ET AL 1960-1975	19 UNDER 2 YEARS	5%	84%		
CHOUX ET AL 1962-1974?	104 4/12-15 YEARS	50%			
MAZZA ET AL 1966-1980	62 0-15 YEARS	47%	50%		3%

Table 2.13 Causes of injury leading to extradural haemorrhage in children

2.3.5 SYMPTOMS:

McKissock et al (228) recorded headache in 32% of their cases and vomiting in 22%. Unilateral headache, ipsilateral

to the extradural haematoma, was present in 13% of patients with headache. Vomiting was particularly common in children, two-thirds of those with this symptom being under fifteen years of age. Jamieson and Yelland (225) maintained that in seven (4.2%) of their patients, headache alone indicated the diagnosis, in a further nine patients (5.4%), headache together with irritability provided grounds for suspicion and in nine more patients the combination of headache, irritability and bradycardia led to diagnosis. In the series of children reported by Hendrick et al (134) vomiting occurred twice as often in patients with extradural haematoma (63%) as in the whole series (30%). The authors considered neither headache nor vomiting was significant of any particular pathology. Hawkes and Ogle (256) reported headache in 44% and vomiting in 31% of their sixteen children and teenagers. In a similar series, Choux et al (223) recorded recurrent vomiting in 53% of cases, the same proportion as Mazza et al (253). Although relatively common in children, vomiting is not very helpful clinically in diagnosis because it is a common symptom of being unwell, often due to intercurrent infection or other illness.

2.3.6 SIGNS:

a) Conscious Level:

Most authors describe several distinct patterns affecting the conscious level and these are detailed below.

i. No Initial Loss Of Consciousness:

All authors agree that a significant proportion of patients do not experience an initial period of unconsciousness. The consensus view is that about a quarter of patients of all ages are not initially knocked out, thus McKissock et al 22% (228), Hooper 25% (212), Gallagher and Browder 33% (211), Kvarnes and Trumpy 26% (226), Heiskanen 24% (248) and Phonprasert et al 27% (229). Cordobes et al (224) put this proportion as being lower i.e., 17%, whereas Jamieson and Yelland (225) found 46% were not knocked out

initially and Mendelow et al (233) reported 41% of their patients with pure supratentorial haematomas did not initially lose consciousness. Series with lower proportions generally had age-distributions skewed to older age-groups (224) while the reverse was true of series with higher proportions (225). This would adequately explain the variations from the consensus, since older patients are more likely to lose consciousness for any given severity of injury than younger patients. This view is supported by a consideration of the history in children. In McKissock's series (228), two-thirds of children under fifteen years were not initially knocked out compared to 84% of children in another large series (134). In the other childrens series considered here, the proportions not initially unconscious were 26% (253), 31% (256), 47% (257), 57% (223). In the latter series the proportion not initially knocked out rose to 85% in infants. Mazza et al (253) also found younger children, under five years, were more likely to remain conscious than older children. As well as age, variations in cause of injury between different series will also affect the proportions of those knocked out or not, as will other factors. For example, in one series 48% of patients with uncomplicated extradural haematoma were concussed compared with 62% of patients with associated intradural lesions (225).

Many of the patients not initially rendered unconscious do ultimately lose consciousness, the range being 35% (226) to 63% (228) in general series and 60% (256) to 81% (253) in children. Rapid progression of deterioration in children is well recognised.

ii. Initial Unconsciousness Followed By Lucidity:

This group is more difficult to define owing to the differences in terminology between series. Allowing for these drawbacks, three broad groups categorised according to the proportion showing this trend in conscious level are recognisable. First a group with a lower proportion in this category, Kvarnes and Trumpy 8% (226), Hooper 11% (212), and Jonker and Oosterhuis 13% (249). Next an intermediate group, Cordobes et al 16% (224),

Jamieson and Yelland 20% (225) and Phonprasert et al 22% (229), and finally a group with a higher proportion initially knocked out and then lucid, Heiskanen 26% (248) and McKissock et al 28% (228). A reasonable estimate for this group might therefore be that it constitutes about one fifth of patients. In McKissock's series (228) this group was comprised mostly of young adults. In another series 61% in this category had uncomplicated extradural lesions and the remainder had associated intradural lesions (225). 13% of children showed this pattern of change in conscious level (253).

iii. Unconscious - Lucid - Unconscious:

This group comprises those patients with a classic lucid interval. Some authors (249) broadened the definition so as to include patients who went through the transition from altered consciousness to lucidity and back to altered consciousness. The proportions of patients showing a lucid interval by this broader definition varied from 11% (226) to 57% (249). In the series described by McLaurin and Ford (227) the patient details which were available allowed the determination of this category in thirty-seven of the forty-seven patients and 92% experienced a lucid interval. This latter figure is almost twice the next highest figure without any apparent reason. The three patients without a lucid interval all had associated intradural lesions. For all series there was some evidence that earlier diagnosis and operation was accompanied by a lower proportion of patients in this category and by a lower mortality (225, 226). Overall this group of patients probably accounts for about 30% of cases but ideally should be much lower than this, which should be possible with the advent of CT scanning.

In McKissock's series (228) patients in this group were evenly distributed as regards age but with some bias towards older age groups. In infants a lucid interval occurred in 32% (257). A little over two-thirds of children upto fifteen years experienced a lucid interval (223). This interval varied from a few minutes upto thirty days and in nearly three-fifths of cases lasted more than twenty-four hours. In another childrens series 40% experienced a

lucid interval and this was less common in children under five years of age (253).

Intradural lesions occurred in three quarters of those patients experiencing a lucid interval in Jamieson and Yelland's series (225). However, all patients without a lucid interval in another series had intradural lesions and all died (227).

iv. Unconscious throughout:

Again there was a fairly wide range from 14% (229) to 40% (226). However in most series the proportion fell between these extremes with most between a fifth and a quarter and nearer the latter. In McLaurin and Ford's series (227) the proportion was not stated. A fair estimate therefore would be that approximately a quarter of patients remain unconscious throughout. Patients in this group tended to be older (228) to have associated intradural lesions (224, 225, 229) and to have the highest mortality (211, 212, 224, 228, 229, 248, 249). In infants and children this group of patients forms a smaller proportion, thus Carcassone et al (257) found 16% of infants were unconscious throughout. For children upto fifteen years the proportions in two series were 20% (223) and 21% (253).

Irrespective of which of the above groups the patient belonged to, the conscious level at the time of operation was related to outcome. In Jamieson and Yelland's group (225) the mortality in patients conscious at the time of surgery was 1.4% and in patients unconscious at the time of surgery was 27%. No patients with uncomplicated extradural haematoma only, who were conscious at the time of operation, died, compared with 3.8% of patients with associated intradural lesions, who were conscious at the time of operation. For patients unconscious at the time of operation the mortality was 13% and 38% respectively for patients with uncomplicated and complicated lesions. The poorer outcome in patients unconscious at the time of operation has been confirmed by other workers (211, 212, 224, 226, 227, 228, 229, 248, 249).

1407. In summary, about one quarter of patients with extradural haematoma will not initially be knocked out, one fifth will be knocked out and then recover consciousness, 30%, but ideally many fewer, will experience a lucid interval and a quarter will be unconscious from the outset until operation or death. Trends in conscious level vary with age and the presence of intradural lesions, and mortality is related to conscious level.

b) Pupillary Signs:

The most important pupillary signs are the development of inequality, dilatation and fixation. Classically the ipsilateral pupil is the first to show any change when it becomes first dilated and later fixed and dilated. Should the same process occur on the other side as well without surgical intervention the patient will die. Hopefully, intervention should occur when the ipsilateral pupil is dilated but still reactive, preferably even earlier, which is possible when CT scan is available.

Some authors only recorded that an abnormality was present, while others defined pupillary abnormality in relation to the side of the haematoma. Pupillary inequality occurred with a range from 31% (248) to 63% (211). Series reporting patients upto and including 1960 tended to have a higher proportion with pupillary inequality averaging about 60% (211, 212, 228). More recent series reported unequal pupils in a smaller proportion averaging about 40% (224, 225, 226, 229, 248, 249). Conversely the proportion of patients with bilateral fixed and dilated pupils tended to be higher in more recent series with a range of 10-26% (224, 229, 249) than in older series when the range was 3-10% (211, 228). Overall therefore any pupillary abnormality occurred in a range from 47-73% and was less common in more recent series with the exception of that reported by Jonker and Oosterhuis (249), 26% of whose patients had fixed, dilated pupils. When inequality of the pupils was related to the site of the haematoma, there was general agreement that in the majority the larger pupil was ipsilateral or on the side of the bigger haematoma if bilateral lesions were present (211, 226, 228,

Of their sixty-one patients with equal pupils, Gallagher and Browder (211) found a slower course in twenty-four (39%). Three had bilateral haematomas, one with pinpoint pupils had been given morphine, and one with bilateral dilated pupils had received atropine drops. Seventeen were moribund with fixed dilated pupils, ten had a rapid clinical course. The same authors reported that nine of twelve patients with contralateral pupillary dilatation had signs of brain-stem involvement and in the remaining three cases no satisfactory explanation was found. McKissock et al (228) recorded eleven patients (8.8%) with contralateral pupillary dilatation, although none showed a widely dilated contralateral pupil. Kvarnes and Trumpy (226) described fourteen patients (11%) with contralateral dilatation and suggested that in some of these, such enlargement was due to an initial transitory constriction of the ipsilateral pupil.

Ingraham et al (254) reported that ipsilateral pupillary dilatation was frequently encountered and unequal pupils occurred in 50%. Hendrick et al (134) reported unilateral pupillary dilatation in 55% of their cases and bilaterally dilated pupils in 2.5%. However only 16% of infants showed ipsilateral dilatation (257). In other series ipsilateral mydriasis occurred in 31% (223) and unequal but reacting pupils were present in 23% (253). Generally, the incidence of eye signs in children was much less than in series dealing with patients of all ages.

Jamieson and Yelland (225) found pupillary abnormalities occurred most often in patients with intradural lesions, patients unconscious at the time of operation (two-thirds) and patients with laterally situated haematomas. Hooper (212) reported pupillary inequality in four of five cases with parasagittal haematomas, ten of fifteen cases with anterior fossa lesions and slightly more than half of all patients with middle fossa haematomas. Not unexpectedly, bilateral fixed and dilated pupils were associated with a higher mortality (225, 229, 249) reaching 100% in one series

(224). McKissock et al (228) had four survivors aged one, two, twenty-seven and forty-one years, while Jonker and Oosterhuis (249) had six survivors out of twenty-six patients with fixed dilated pupils, four of whom were under thirty years old.

Di Tullio (258) has described a case of complete paralysis of the third cranial nerve ipsilateral to a large extradural haematoma. The young boy concerned had been kicked on the right side of the head whilst playing gridiron football, twenty-eight hours prior to admission. He was not knocked out, but after several hours developed a throbbing headache and vomiting and the following day developed diplopia and ataxia. On admission the only abnormality detected was the third nerve palsy, no external evidence of head injury was apparent and skull X-ray was normal. However a small stellate fracture was found at operation, although again no other external evidence of injury was discovered.

c) Hemiparesis:

Generally speaking, in those articles dealing with patients of all ages, hemiparesis was more common than pupillary inequality. Both McKissock et al (228) and Gallagher and Browder (211) recorded hemiparesis, nearly always contralateral, in about two-thirds of their cases. However, Jamieson and Yelland (225) found this sign in half as many patients. The one third of patients with hemiparesis more often had intradural lesions, a lucid interval and unconsciousness at operation, but less commonly had basal or posterior fossa lesions. Three quarters of the cases in another series had either a hemiparesis or other pyramidal symptoms and in 8% of these, such lesions were ipsilateral (249). McLaurin and Ford (227) recorded hemiparesis in 47%. A focal motor deficit was present in about a quarter of the patients described by Cordobes et al (224). In McKissock's series (228) patients with an ipsilateral hemiparesis all had slower developing haematomas of more than one weeks duration. In another series four out of six patients with an ipsilateral hemiparesis developed symptoms within two hours of injury, although the authors did not disclose when these patients

were operated on (249). Ipsilateral weakness occurred in two patients described by Gallagher and Browder (211). Both these patients died, and at post-mortem extensive bilateral lacerations of the brain were present. Hemiparesis, contralateral in at least 94%, was present in 45% of all cases described by Heiskanen (248). Ipsilateral third nerve palsy combined with contralateral hemiparesis was present in 42% of cases with weakness and contralateral third nerve palsy combined with contralateral hemiparesis occurred in 5.6%.

In infants a hemiplegia or hemiparesis occurred in 53% and such signs were more common in infants than in children (257). Ingraham et al (254) reported that in their series of twenty children with extradural haematoma, hemiparesis was usually noted (65%). In a large series reported from Canada, one quarter of children with an extradural haematoma had a hemiparesis and a further 5% had weakness of one leg only (134). A higher incidence (31%) was recorded in the sixteen patients discussed by Hawkes and Ogle (256). Pyramidal signs, always contralateral, appeared in 41% of the one hundred and four children described by Choux et al (223), whereas Mazza et al (253) in their recent series discussing sixty-two cases in children reported the same incidence as Hawkes and Ogle. Overall, therefore, the incidence of hemiparesis in childhood cases is somewhat less than in general series. This was confirmed by Jamieson and Yelland (225), who reported hemiparesis in 14% of their subgroup of children upto ten years, compared to one third of all cases.

d) Other Signs:

Decerebrate rigidity varied in incidence from 5.4% (249) to 43% (211). Within this range there was no clear consensus although of the seven series mentioning this finding (211, 224, 227, 229, 248, 249) an incidence of 28% or higher occurred in four and of 15% or lower in three. Gallagher and Browder (211) found decerebration was only apparent on stimulation; in about four-fifths decerebration was bilateral and in the remainder unilateral decerebration was

always contralateral to the haematoma. Phonprasert et al (229) and Cordobes et al (224), however, both reported unilateral decerebration was more common than bilateral decerebration, with about 60% showing unilateral signs. All authors agreed mortality was higher in patients with decerebrate rigidity and was higher in patients with bilateral rigidity than in those with unilateral decerebration. Thus Jamieson and Yelland (225) reported a mortality of 78% in patients with decerebrate rigidity compared with a mortality of 16% for all patients. Other series reported the following mortality: 34% (224), 39% (229), 67% (248), and 69% (249). Cordobes et al (224) found mortality was twice as high in patients with bilateral decerebration (50%) as in patients with unilateral decerebration (24%) and Phonprasert et al (229) found a threefold increase in mortality in patients with bilateral (69%) as compared to unilateral decerebration (23%).

Decerebrate posturing occurred in 25% of the childhood cases described by Ingraham et al (254) and in only 11% of infants (257). Choux et al (223) found decerebration in 18% of their one hundred and four children. Verdura et al (259) reported two cases of complete recovery following removal of acute extradural haematomas in children, both had bilateral decerebrate rigidity and cardiac arrests prior to operation.

Papilloedema is neither a common nor an early sign in patients with extradural haemorrhage. McKissock et al (228) noted this sign in 14%, the earliest being found at six hours and the majority occurred in slowly developing cases, half more than one week after injury. Only 55% of the cases in another series had their fundi examined and 44% of these (24% of all cases) had papilloedema; in 38% of the cases with papilloedema, this finding occurred in patients operated on more than one week after injury (249). McLaurin and Ford (227) reported papilloedema led to surgical intervention in 6.4% of their cases. In a childhood series, unilateral papilloedema occurred in 5% and bilateral papilloedema in 18% (134). In the two cases (13%) with papilloedema in another small series of children, this sign was evident on the

fourth and sixth days respectively (256). Papilloedema was not mentioned in a series of infants (257) or other children (223, 253). Hooper (212) reported that papilloedema occurred in the delayed types of posterior fossa haematoma.

Exophthalmos is a rare sign in patients with extradural haemorrhage but individual cases have been reported by several authors (236, 237, 260). In the cases reported by Watts (260) the exophthalmos was contralateral, whereas the four cases described by Gruszkiewicz (236, 237) were ipsilateral and all had subfrontal haematomas and linear frontal fractures. Operation in these latter cases was performed between two and ten days after injury and the exophthalmos persisted for two to six weeks. 1.6% (1 patient) of children had exophthalmos and again the haematoma was subacute and subfrontal (253). Retinal and subhyaloid haemorrhages are more often mentioned in children. Thus 7.5% and 5% of children with extradural haematomas showed unilateral or bilateral retinal haemorrhages respectively (134). Two of the sixteen cases described by Hawkes and Ogle (256) showed subhyaloid haemorrhages.

Dysphasia occurred in eight patients (6.4%) in McKissock's series (228) and all had left-sided extradural bleeds. Homonymous hemianopia occurred in only two cases from the same series and in both cases was contralateral. Dysphasia was also infrequent (2.5%) in Heiskanen's series (248) whilst facial paresis was half as common (1.3%). Cordobes et al (224) reported dysphasia in 7.3% and papilloedema in 4.8%.

Convulsions occurred in a small proportion of patients of all ages - 2% (249), 4.8% (224), and 5% (228). However they were more common in children's series - 7.5% (134), 10% (254) and 11% (223, 257), although Mazza et al (253) recorded the much lower incidence of 1.6%.

Although classical, bradycardia is an uncommon finding. Bradycardia was more common in older series, 46% (228), 51% (211), than in more recent series, 20% (225), 24% (224, 249), and was least

common in childhood series, 10% of infants (257), 9% (223), 21% (253). In Jamieson and Yelland's (225) experience, bradycardia was more common in patients with frontal, basal or posterior fossa haematomas, in patients conscious at operation, in patients with intradural lesions and in patients who experienced a lucid interval. Jonker and Oosterhuis (249) found an increased mortality occurred in patients with a pulse greater than 100 (81% died) compared to patients with a pulse less than 60 (33% died). Hypertension occurred in less than one tenth of Australian patients and was commoner in patients with intradural lesions or unconscious at operation (225). Jonker and Oosterhuis (249) found a blood pressure greater than 150/90 in 15% of their cases and 60% of them died.

Hypotension due to head injury alone only occurred in infants (228, 254). McLaurin and Ford (227) reported changes in pulse, blood pressure and respiration led to surgical intervention in only one patient (2.1%). Severe respiratory disturbances occurred in 14% of cases described by McKissock et al (228).

2.3.7 EVIDENCE OF LOCAL INJURY:

External signs of head injury may not always be apparent, only becoming so when the scalp is shaved (212, 232) or incised (258). However in most cases local evidence of injury is present and is usually located over the site of the haematoma (212, 228). In Hooper's series (212) 84% had a scalp abrasion or haematoma overlying the extradural haematoma, 13% had no external signs of injury and in 3% the lesion did not underlie the external signs of injury. Thus the site of impact and the external evidence of injury usually indicate the site of the lesion, e.g., signs of frontal impact were present in cases of anterior fossa extradural haematoma and of occipital blows with posterior fossa lesions. This external evidence of injury was a slightly more reliable guide than the site of any skull fracture and in the absence of a fracture should determine the site of initial burr hole (212). These observations were confirmed by Gallagher and Browder (211) who found only 8% had

no external evidence of injury. Kvarnes and Trumpy (226) found evidence of scalp injury related to the position of the extradural haematoma in 71%, rather fewer than Hooper. Ingraham et al (254) reported swelling of the scalp usually overlying a fracture was a common sign in their cases.

2.3.8 SKULL FRACTURE:

This special instance of evidence of local injury will be treated separately because of its importance. An absolute correlation between skull fracture and extradural haematoma is difficult to determine since not all authors record this finding in all patients. Also, quite rightly, not all patients are X-rayed, since this would sometimes cause unforgivable delay in treatment. In some cases therefore, fractures may only be found at operation or post-mortem, although again, not all authors record this finding. The incidence of skull fracture in general series and childrens series is shown in Tables 2.14 and 2.15 respectively. Figures not in parentheses indicate the number of patients in whom the presence or absence of a fracture was definitely known and percentages of all patients are based on this figure rather than the total number of patients in the series, which are the figures in parentheses. Hooper (212) reported fractures in twenty-two of twenty-four patients with anterior or posterior fossa haematomas and stated fractures were present almost without exception in cases of middle fossa haemorrhage (54 patients) but did not refer to the presence of fractures in the small group of parasagittal haematomas (5 cases). Proportions with fractures include patients with diastasis.

Kvarnes and Trumpy (226) reported 86% of patients who were X-rayed had a fracture related to the site of the haematoma, presumably some patients had a fracture unrelated to the site of the haematoma. In McKissock's series (228) 77% were X-rayed compared with 82% in Phonprasert's (229) and 83% in Cordobes' series (224), but 100% in Gallagher's series (211). A radiologically detectable fracture therefore occurred in 75-89% of patients of all ages who were X-rayed. The proportion was lower in series where more

AUTHOR & YEAR STUDIED	No. OF PATIENTS AND AGE RANGE	% OF X-RAYED PATIENTS WITH SKULL FRACTURES	% OF "ALL PATIENTS" WITH SKULL FRACTURES
McKISSOCK ET AL 1941-1959	125 (125) ALL AGES	89%	85%
HOOPER 1947-1958	24 (83) ALL AGES		92%
GALLAGHER + BROWDER 1935-1960	167 (167) ALL AGES	84%	91%
McLAURIN + FORD 1951-1962	40 (47) ALL AGES		88%
JAMIESON + YELLAND 1956-1967	? (167) 9/12-84 YEARS		65%
REDDY ET AL ? 1958-1959	100 (100) 4-70 YEARS		91%
JONKER + OOSTERHUIS 1961-1973	94 (100) ALL AGES		86%
KVARNES + TRUMPY 1964-1975	? (132) ALL AGES	86%	
PHONPRASERT ET AL 1971-1978	? (138) 3-71 YEARS	75%	63%
CORDOBES ET AL 1973-1980	68 (82) ALL AGES	76%	88%

Table 2.14 Incidence of skull fracture in patients with extradural
haematoma.

AUTHOR & YEAR STUDIED	No. OF PATIENTS AND AGE RANGE	% OF X-RAYED PATIENTS WITH SKULL FRACTURE	% OF "ALL PATIENTS" WITH SKULL FRACTURE
INGRAHAM ET AL ? 1948	20 (20) 0-12 YEARS		95%
HAWKES + OGLE 1946-1961	11 (16) 3/12-18 YEARS	78%	91%
HENDRICK ET AL 1954-1962	40 (40) 0-15 YEARS		40%
CARCASSONE ET AL 1960-1975	19 (19) 0-2 YEARS	84%	84%
CHOUX ET AL 1962-1974?	104 (104) 4/12-15 YEARS	60%	79%
MAZZA ET AL 1966-1980	62 (62) 0-15 YEARS	76%	85%

Table 2.15 Incidence of skull fracture in children with extradural haematoma

patients were X-rayed. In the only series where all patients were radiographed, the proportion with fracture on X-ray was 84% (211).

In children a more divergent picture is found, 40-76% of children upto fifteen years old and 84% of infants having a fracture proven radiographically. In the studies reported by Hendrick et al (134) and Harwood-Nash et al (217), forty patients under fifteen years old were stated to have extradural haematomas and only 40% had a fracture at operation or post-mortem or on X-ray. However a

further nineteen patients with extradural haematoma associated with severe brain damage were excluded (217). The likelihood of fracture in these nineteen patients would be high, thus the figure of 40% underestimates the true incidence of skull fracture in children with extradural haematomas.

When diagnosis of fracture is expanded to include cases diagnosed radiologically, at operation or at post-mortem the proportion with fracture ranges from 63-92% for patients of all ages. The incidence quoted by Jamieson and Yelland (225) and Phonprasert et al (229) may be discounted since in many instances the presence or absence of fracture was not documented. The next lowest incidence was reported by Cordobes et al (224). Fourteen of their eighty-two cases did not have X-rays of the skull and in none of these cases was a fracture stated to have been found at operation or at post-mortem, nor was a fracture stated not to have been found by these means. In the sixteen patients with negative skull X-rays, half had fractures demonstrated at operation. It would seem likely therefore that at least some of the fourteen patients not X-rayed would have a fracture, so that the overall proportion of 73% represented an underestimate of the true incidence. Discounting the results of these three series, the proportion of patients with skull fracture diagnosed by any means, ranged from 85-92% (211, 212, 227, 228, 249, 255). An average incidence of 90% would seem reasonable. Once again the range in childhood is broader, 69-95% (223, 253, 254, 256) and 84% of infants have a fracture (257). The high incidence in Ingraham's series (254) can be explained by the fact that 55% of the cases were infants who have a higher incidence (257) than all children (223, 253, 256). In two post-mortem studies the proportions of patients with extradural haematoma who also had skull fractures were 98% (184) and 94% of supratentorial lesions (193).

Mealey (261) has discussed the occurrence of supratentorial extradural haematoma without skull fracture based on a series of thirty-four cases. Fractures were absent on X-ray or at operation in six cases (18%) aged eleven (2 patients), thirteen, fourteen, fifteen and forty years respectively. All of the children were

operated on within thirty hours and four of the five in less than half this time, the only adult patient came to operation three days and seven hours after injury. In addition, none of the children suffered a documented initial period of unconsciousness. One of the children had contralateral displacement of a calcified pineal gland. Mortality in the group of children without fracture was 20% and for the whole series of thirty-four cases was 21%. After describing his own cases without fracture, Mealey went on to review other published studies. He found twenty-one cases of extradural haematoma without fracture in which the ages were known. In an additional twelve cases the ages were unknown. If these twenty-one cases were added to his own six cases then two-thirds were under fifteen years of age and only 11% were thirty years or older. Furthermore, 83% of the children under fifteen years were not knocked out initially. The greater resilience of the skull in children was believed by the author to adequately explain the lower incidence of fracture in this group. In a similar more recent study, Galbraith (250) concluded that 91% of patients with extradural haematoma unaccompanied by skull fracture were under thirty years old. This author included the twenty-seven patients already described by Mealey, as well as nine patients from McKissock's series (228) and ten cases from Glasgow. In Reddy's series (255) 9% did not have a fracture on skull X-ray and all were aged 21-30 years. Jonker and Oosterhuis (249) reported 13% had no fracture on X-ray or at operation and eleven of these (85%) were under thirty years of age. They further stated that the absence of a fracture enhanced survival irrespective of age.

In summary therefore, we can say that in unselected series of patients with extradural haematoma, about 84% will have a skull fracture on X-ray and about 90% a fracture on X-ray, at operation or at post-mortem. In children these proportions are lower, perhaps 70% and 80%. Accordingly, the majority of patients who do not have a fracture are children and 90% are under thirty years old. When patients diagnosed only on clinical grounds are added, the proportion of patients with fractures will rise.

As well as knowing if a fracture is present or not, the site of the fracture is important since in most cases the haematoma will be underneath (211, 212). In those patients in whom the fact was definitely known, 78% had an extradural haematoma below the fracture, in 10% the fracture did not overlie the haematoma and in the remainder no fracture was present (227). In another series, 86% of cases had a skull fracture related to the site of haematoma (226) and in another, 87% of those with fractures on X-ray (65% of all patients) had an underlying haematoma (229). In Cordobes series (224) two patients (2.4% of all patients, but 3.3% of cases having a fracture on X-ray or at operation) had a fracture on the side opposite to the haematoma. Choux et al (223) reported that in 8.3% of childhood cases the haematoma did not correspond with the site of the fracture, this includes one case (1%) in which the fracture was contralateral. However Mazza et al (253), also reporting on children, stated that in all cases with fracture the haematoma corresponded to the fracture site. The site of the skull fracture correctly identifies the side of the haematoma in 86-100% of cases (223, 224, 226, 229, 253) and the exact location of the haematoma in 78%-100% of cases (223, 224, 226, 227, 229, 253).

2.3.9 SITE OF HAEMATOMA:

Because extradural haematoma does not always fall neatly within anatomical boundaries and because of differences in classification comparing different series is more difficult. Nevertheless the anatomical distribution of lesions is shown in Table 2.16 and includes both general and childhood series. In some cases to facilitate comparison only the distribution of localised lesions has been depicted. In general and in keeping with the most common source of the bleeding, most authors found temporal lesions to be the most common. The incidence varied from 46% of localised haematomas (65% of all cases) in Phonprasert's series (229) to 85% in McLaurin's series (227). Frontal haematomas accounted for about 10-12% of most general series (216, 224, 225, 226) but about one in three childhood cases (223, 253). Conversely, parietal lesions were less common in children, where they accounted for about 17% of

AUTHOR	FRONTAL	TEMPORAL	PARIETAL	OCCIPITAL	POSTERIOR FOSSA
McKISSOCK ET AL	7%	80%	9%		4%
HOOPER	18%	65%	6%		11%
McLAURIN + FORD	2%	85%	9%	2%	2%
JAMIESON + YELLAND	11%	70%		7%	7%
RAO ET AL	10%	53%	13%		2%
KVARNES + TRUMPY	11%	58%	25%		5%
PHONPRASERT ET AL	18%	46%	25%	7%	4%
CORDOBES ET AL	12%	52%	31%	5%	1%
CHOUX ET AL	33%	48%	17%	2%	3%
MAZZA ET AL	31%			3%	2%

Table 2.16 Distribution of extradural haematoma by site.

localised haematomas (223), than in general series where they constituted about a quarter of cases (226, 229). Posterior fossa lesions were least common, averaging about 4%. These lesions have been discussed separately in case reports by Hooper (235), Arkins et al (230), Devadiga et al (231), Hulvat et al (262), McCulloch (232)

and Sadik et al (234). Several of these latter authors confine their discussion to childhood cases (230, 231, 234, 262).

Bilateral extradural haematomas occur infrequently. The incidence in the above series varied from 1.2% (224) to 3% (225). Biparasagittal haematomas have been described by Weinman and Samaratunga (241) and by Plaut and Gifford (213). The former authors reported such lesions occurred in 5% of two hundred and twenty-four cases of extradural haematoma, whereas in the same series 48% were temporal, 25% parietal, 19% frontal, 2% occipital and 1% in the posterior fossa. Most biparasagittal lesions resulted from blows to the head by a club or sword. Two-thirds of cases presented two to fourteen days after injury. A lowering of the conscious level occurred in 83%, bradycardia in 67%, papilloedema in 75% and pupillary inequality in only 17%. Three-quarters had a fracture on skull X-ray. In 83% bleeding was from lateral venous lacunae. Death occurred in two cases (17%). Soni (239) reported a case of asymmetric bilateral haematomas (right temporal and left frontal). The frontal haematoma corresponded to the site of impact, however the temporal haematoma presented first clinically, at about two hours following injury and was evacuated. The frontal haematoma was revealed by angiography following neurological deterioration about fifty hours after injury. This difference in the rate of development between frontal and temporal lesions is in accord with Hooper's observations on the relative speed of evolution of the two types (212).

A small series of eleven bilateral lesions has been described by Subrahmanian et al (240). These patients constituted 22% of forty-nine cases of extradural haematoma treated during a four year period. This incidence is rather high in comparison to the series referred to above. Most cases (64%) resulted from assaults, all eleven patients were male, five had bilateral and three had unilateral fractures on X-ray and an additional three patients had a fracture found at post-mortem. Three patients had accompanying subdural haematomas, bilateral in one case, and one patient had an intracerebral haematoma, cerebral lacerations and

contusions were present in six cases. In four cases (36%) diagnosis was first made at post-mortem and all patients died finally.

Several authors have reported that mortality varied with the site of the extradural haematoma. Thus Hooper (212) recorded a 44% mortality in cases of posterior fossa haematoma, 25% with middle fossa and 20% with anterior fossa lesions. Gallagher and Browder (211) also found a lower mortality in frontal and occipital haematomas than in temporal haematomas. They attributed this finding to the more rapid accumulation of temporal lesions and to the fact that such lesions are more apt to cause fatal brain-stem compression more quickly. This view was shared by McLaurin and Ford (227) who earlier confirmed this proposition in their experiments with dogs (210). Jamieson and Yelland (225) had no deaths in patients with frontal or vertical lesions, owing to their slower evolution and tendency to remain conscious. Posterior fossa lesions had the highest mortality (33%) followed by occipital lesions (20%). Mortality in the latter group is thus high compared to temporal lesions, a direct contradiction of the findings of Gallagher and Browder (211) and McLaurin and Ford (227). The incidence of intradural lesions in cases with extradural haematoma at different sites did not appear to account for differences in mortality. Kvarnes and Trumpy (226) also disagreed with Gallagher and Browder (211) and McLaurin and Ford (227) since their mortality rates in patients with frontal, temporal and parietal haematomas were 27%, 18% and 24% respectively. Cordobes et al (224) found mortality much the same in patients with frontal (27% died) and temporal haematomas (26% died) but less than half this value in cases with parietal haematomas (12% died). In a series of children, mortality in convexity haematomas was 20%, in frontal haematomas 11% and in posterior fossa lesions 100% (253).

2.3.10 INTRADURAL LESIONS:

Again there is a good deal of variation in the incidence of these lesions, some authors counting only additional haematomas, others counting lacerations and contusions as well. Furthermore,

in some cases, owing to more than one additional lesion per patient being present, the figures are not sufficiently clear to allow definite proportions to be determined for each type of lesion. McKissock et al (228) reported that twelve cases (10%) had additional haematomas, all subdural, and in two of these cases an intracerebral haematoma was also present. Two-thirds of these lesions were ipsilateral to the extradural haematoma. Additional haematomas occurred in 39% of Hooper's patients (212), more than one-third having both subdural and intracerebral haematomas and nearly three-quarters had talked at some time after injury. Jamieson and Yelland (225) recorded subdural and intracerebral haematomas, cerebral lacerations or combinations of these in 47% of patients. In two other series the proportions with subdural haematomas and/or cerebral lacerations or contusions were 24% (249) and 32% (226) respectively. Heiskanen (248) found 31% had intracerebral haematomas or cerebral contusions although in two-thirds the diagnosis of contusion was clinical. McLaurin and Ford (227) found accompanying subdural haematomas in 15% and cerebral contusion in an additional 32%. Subdural and intracerebral haematomas, cerebral contusions and lacerations occurred in 31% of the series from Thailand (229) and 35% of the cases from Spain (224). In a childhood series, accompanying subdural haematomas were present in 13%, contusion in 10% and coning in 10% (223). In another similar series reported by Mazza et al (253), 39% had associated lesions: cerebral contusion alone (18%), subdural haematoma alone (4.8%) and both (16%). Overall therefore about one third of patients have associated intradural lesions either singly or in combination and approximately half of these are additional haematomas, mostly subdural.

Patients with intradural lesions were twice as likely to be unconscious at the time of operation and were also more likely to have been unconscious since the outset, or to have been initially knocked out (225). These same authors also found pupillary inequality, hemiparesis and bradycardia to be more common in patients with intradural lesions, as was the occurrence of a lucid interval. Cordobes et al (224) recorded unconsciousness throughout

in 55% of cases with intradural lesions and only 24% of patients without such lesions, which confirms Jamieson's findings. However these same authors differed from Jamieson in other respects since a lucid interval was less common in patients with intradural lesions and equal proportions of patients with and without intradural lesions were conscious throughout.

Hooper (212), Jamieson and Yelland (225) and Phonprasert et al (229) all reported mortality was four times as high in patients with intradural lesions as in patients without such lesions. In McLaurin and Ford's cases (227), mortality was two and a half times higher in patients with subdural haematomas and five times higher in patients with cerebral contusions. This excess mortality in patients with intradural lesions has been confirmed by other workers (211, 223, 224, 226, 228, 248, 249, 253). In one series the mortality in patients with intradural lesions was 75%, compared to 25% in patients with pure extradural haematomas (249).

2.3.11 INTERVAL TO OPERATION:

Five series record almost the same proportion operated on in the first twenty-four hours, the proportions being 53% (228), 54% (229), 55% (225) and 59% (227, 248). McKissock et al (228) and Heiskanen (248) found a significantly slower evolution of the lesions in children, more children than adults being operated on after the first twenty-four hours. Thus McKissock et al (228) reported 63% of children and only 42% of adults came to operation after the first day, whereas Heiskanen (248) found the proportions to be 40% and 26% respectively. However, Jamieson and Yelland (225) found little variation with age, except that children came to operation a little earlier and teenagers a little later than average. In two other series a much higher proportion (73%) came to surgery on the first day (226, 249). Five patients who died unoperated on were included in this figure in one series (249), whereas all the patients had been operated on in the other series (226).

There was more variation between different series for patients coming to operation between one day and one week after injury, in part because of differences in selection of time intervals. McKissock et al (228) reported that 29% of all cases (41% of children + 26% of adults) were operated on one to six days after injury whereas 17% of another series were operated on one to five days after injury (227). 38% of Jamieson's patients (225) and 15% of Jonker's patients (249) were submitted to surgery between the end of the first day and the end of the first week. During the same period a further 40% of Phonprasert's patients (229) came to operation. After the first week the proportions operated on were 5% (225, 229), 12% (249) and 17% (228) and after ten days were 7% (226) and 9% (227, 248).

In a series of sixteen cases in children upto eighteen years, 44% were operated on during the first twenty-four hours and the same proportion after forty-eight hours (256). In a larger series 77% were operated on during the first twenty-four hours (253).

Patients who required operation earlier had a higher mortality (212, 225-229, 248, 249). The mortality among patients operated on during the first twenty-four hours varied from 22% (225) to 51% (249). After this time had elapsed mortality was lower. Jonker and Oosterhuis (249) and Heiskanen (248) had no deaths in patients coming to operation after twenty-four hours. In each series that sub-divided the first day, mortality was higher in more acute lesions (212, 225, 226, 227) except for Phonprasert's series (229) when the mortality in the first six hours was 23% and in the first twenty-four hours was 24% and after this only 6%.

Frontal lesions developed more slowly and had the lowest mortality (211, 212, 225, 253) whereas posterior fossa lesions had the highest mortality (212, 225, 253) and evolved at the same rate as lateral lesions (225) while occipital lesions developed more quickly (225). Phonprasert et al (229) maintained that except for lesions at the vertex, the site of haematoma was not correlated with the rate of development of clinical signs. Patients unconscious at

operation had a faster rate of development than those conscious at operation (225, 226) and evolution was slowest in patients conscious throughout (225). Pupillary abnormality developed much faster than other signs and two-thirds of those cases with bilateral fixed dilated pupils came to operation within twenty-four hours (225). Three quarters of all patients operated on within twelve hours and half operated on within forty-eight hours had pupillary signs (225). When extradural haematoma was present on its own, mortality was little affected by the rate of development, but when intradural lesions were also present, rapid development and increased mortality occurred (225). Thus for pure lesions, mortality in the first twenty-four hours was 5%, but for cases with intradural lesions was 35% (225). The corresponding figures for the series reported by Kvarnes and Trumpy (226) were approximately 14% and 39%.

2.3.12 MORTALITY:

In 1959 Hooper (212) suggested that a mortality of 10% for a series of patients with extradural haematoma was reasonable where neurosurgical facilities existed, but a rate of more than 28% indicated poor education or organisation. This statement has since often been used as a yardstick by neurosurgeons when discussing such patients. The mortality rates of the series considered here are shown in Tables 2.17 and 2.18. Most authors have sought factors which have an adverse effect on mortality and the following such factors have been identified.

a) Conscious Level at Operation:

Not unexpectedly, patients conscious at the time of operation have a much lower mortality than patients with a worse conscious level. No patients alert at the time of operation died, compared with a mortality of 9% and 12% in drowsy patients and 33% and 35% in comatose patients in the same series (212, 228). These figures are taken from Table VII in McKissock's paper (228) and would appear to correspond to the mortality in Hooper's paper (212), except in regard to comatose patients when mortality in Hooper's

AUTHOR AND YEAR	NUMBER OF PATIENTS AND AGE RANGE	SURGICAL MORTALITY	OVERALL MORTALITY
McKISSOCK ET AL 1941-1959	125 ALL AGES	22%	27%
HOOOPER 1947-1958	83 ALL AGES	22%	23%
GALLAGHER + BROWDER 1935-1960	167 3-75 YEARS	39%	56%
McLAURIN + FORD 1951-1962	47 ALL AGES	27%	30%
JAMIESON + YELLAND 1956-1967	167 9/12-84 YEARS	16%	
RAO ET AL 1958-1971	96 4-62 YEARS	16%	18%
JONKER + OOSTERHUIS 1961-1973	100 ALL AGES	32%	37%
KVARNES + TRUMPY 1964-1975	132 ALL AGES	23%	
HEISKANEN 1967-1971	80 ALL AGES	13%	16%
PHONPASERT ET AL 1971-1978	138 ALL AGES	15%	16%
CORDOBES ET AL 1973-1980	82 ALL AGES	21%	

Table 2.17 Mortality rates in series of patients with extradural haematoma.

AUTHOR AND YEAR	NUMBER OF PATIENTS AND AGE RANGE	SURGICAL MORTALITY	OVERALL MORTALITY
INGRAHAM ET AL 1948	20 0-12 YEARS	10%	
HENDRICK ET AL 1954-1962	40 0-15 YEARS	3%	10%
HAWKES + OGLE 1946-1961	16 0-18 YEARS	7%	13%
CARCASSONE ET AL 1960-1975	20 0-2 YEARS	16%	
CHOUX ET AL 1962-1974?	104 4/12-15 YEARS	17%	
MAZZA ET AL 1966-1980	62 0-15 YEARS	18%	18%

Table 2.18 Mortality rates in series of children with extradural haematoma.

series was 33% and not 35% as quoted by McKissock (228) or 34% as quoted by the author himself (212). Assuming the definitions of comatose, stuporose and other were the same in both series, then the mortality rates in these groups were 55%, 14% and 7% respectively in McKissock's series (228) and 33%, 12% and 6% in Hooper's series (212). If stuporose and comatose patients were grouped together, then in McKissock's series (228) mortality was 33% and in Hooper's (212) 28% and in the remaining patients 7% and 6% respectively. Other authors confirmed the higher mortality in patients with a worse conscious level at operation (211, 223-227, 229, 248, 249,

253). Of patients unconscious throughout, mortality varied between 25% (248) and 100% (253), for patients with a lucid interval between 14% (224) and 33% (249), for patients conscious at operation between 0% (249) and 5% (224) and for patients unconscious at operation about 25% died (224, 225, 229).

b) Age:

McKissock et al (228) had no survivor over sixty years of age and mortality rose from 7% in children (0-15 years) to 25% in 15-30 year olds, 33% in 30-45 year olds and 47% in 45-60 year olds. Increasing mortality with increasing age was found by other workers also (212, 216, 224, 225, 227, 229, 248, 249). In the childhood series mortality was usually less than in the general series. In the latter series some of the variations in mortality could be adequately explained by the differing age-distributions. For example, series with higher mortality rates (211, 224, 226, 249) generally included more elderly patients than series with lower mortality rates (216, 225, 229, 248). In Heiskanen's series (248), the mean age of those dying was forty-four years, of those disabled was thirty-four years and of those who recovered twenty-nine years.

c) Intradural Lesions:

The impact on mortality of the presence of intradural lesions has already been discussed in sections 2.3.10 and 2.3.11 and applied equally in general series and in children.

d) Rate Of Development:

This factors influence on mortality has also been discussed in section 2.3.11. The mean interval between injury and operation in ten fatal cases was six hours and nineteen minutes in Heiskanen's series (248) compared with seventeen hours and fifty minutes in disabled survivors and more than seventy-two hours in those who recovered.

e) Site of Haematoma:

Variations in mortality with the site of the lesion have been confirmed by most authors and was discussed in section 2.3.9.

f) Delay in Diagnosis or Treatment:

Unfortunately, this factor is the most common reason for patients dying (unnecessarily) and its importance has been stressed by most authors (211, 212, 216, 224-229, 248, 249, 255, 263). Furthermore, this particular aspect has been the basis of articles by Galbraith (78) and Mendelow et al (233). It should be possible to drastically reduce the extent to which this factor operates. McKissock et al (228) pointed out that teaching, which stresses the clinical presentation of extradural haematoma with a lucid interval, does patients a disservice since this presentation is uncommon, only 27% in their series. This view is shared by Tandon (263) who attributed delay in diagnosis to this prevalent misconception of the clinical picture of extradural haematoma. McKissock et al (228) reviewed their mortality and calculated that fifteen patients (44% of all deaths) might have survived with better management and most of these patients had less severe concomitant cerebral injury. Half of these unnecessary deaths occurred in patients with a classic lucid interval and the remainder in patients not initially knocked out who subsequently became unconscious. Accepting that all their cases were secondary referrals, they went on to say that earlier diagnosis and referral (i.e., avoidance of delay) would have saved more patients. Other errors in management included lesions missed at operation (7 cases), co-existing lesions missed at operation (3 cases) and inadequate operation (2 cases). Eight patients died prior to operation, two within a few minutes of admission, and all of them were adults.

Hooper (212) believed delay was the major factor behind most deaths, being present in thirteen (68%) of his nineteen fatal cases. Delay occurred prior to admission in four cases and while the patient was being "observed" in the remainder. The clinical

presentation was clearly that of an expanding mass lesion in nine cases (69%) and four of these nine patients corresponded to the classical description.

Only 73% of the one hundred and sixty-seven patients in Gallagher and Browder's series (211) came to operation. Of the operated cases, forty-eight died, and in ten (21%) of these death was due to delay. In a further twenty-nine patients who were operated on and died, the patients were in extremis from the outset, however, the preceding details of these patients were not given e.g., time elapsed or whether they were secondary referrals. It is conceivable therefore that delay was responsible for fatalities in at least some of these patients. In the nine remaining patients diagnosis was prompt and treatment appropriate. Delay also occurred in some of the forty-five unoperated cases. Seventeen died within minutes of admission, eight died on an alcoholic ward without the benefit of neurosurgical opinion, eight more were admitted to a neurosurgical ward with a complicated clinical picture and the correct diagnosis was never made, five patients had clots missed at operation, five showed clinical evidence of the presence of a clot but were not operated on, one child died suddenly and unexpectedly whilst under observation and one patient's family refused treatment. Altogether, therefore, at least twenty-four patients died as a result of delay - 26% of all deaths.

McLaurin and Ford (227) identified errors in management in six patients who died (43% of all deaths), but whose lives could have been saved. In five cases there was a failure to recognise deterioration clinically and in the remaining patient, as well as in one of the five already mentioned, excessive delay occurred between diagnosis and treatment. Reporting on one hundred and sixty-seven patients, all submitted to surgery, Jamieson and Yelland (225) recorded a mortality of 16% (26 cases). The incidence of a lucid interval in their series was among the lowest found. When surgery was delayed until the lucid interval was completed, the mortality was almost the same as when the patient had been unconscious throughout. The authors attributed the significantly lower

mortality (8%) in their latter sixty patients to the avoidance of delay by the earliest possible diagnosis, the criteria for which was any deterioration in conscious level. Thus the appearance of the classical picture was prevented by early recourse to surgery. Awaiting the development of the textbook picture can only lead to more deaths, and even delay for skull X-ray may be unacceptable when the diagnosis and localisation can be made clinically. The outstanding avoidable cause of death in their opinion was undue delay in diagnosis and treatment.

The mortality in patients who were transferred over a distance greater than twenty-five kilometres was 78% in one series and of patients travelling less than this distance was about a third (249). The same author considered delay in diagnosis was in part due to the low incidence of a lucid interval. In eight unoperated patients who died, misdiagnosis occurred in three and one lesion was missed by a last ditch burr hole. Delay was also cited by Kvarnes and Trumpy (226) as being responsible for a fatal outcome, especially in patients whose conscious level had deteriorated. In another series from Scandinavia, errors in management were considered to have occurred in eleven patients (14%) and in ten of these delay at the referring hospital or at the neurosurgical unit was implicated (248). In almost half of both fatal and disabled cases the reason for the poor outcome was delay in diagnosis and treatment.

In a series from Thailand, four deaths (18% of all deaths) were believed to result from delayed diagnosis and treatment (229). A further three deaths were attributed to management errors, leaving an unavoidable mortality of 11%. Cordobes et al (224) reported a series of eighty-two patients, half were treated before the advent of CT scanning and half after this became available. Mortality in the earlier period was 29% and in the later period 12%. A similar decline in morbidity was found. The two groups had similar age-distributions, incidence of intradural lesions and sites of clots. They attributed the difference in mortality to earlier diagnosis during the latter period. Significantly more patients

were operated on when conscious during the CT era.

Mendelow et al (233) undertook a retrospective study of extradural haematoma occurring during two decades, 1951 to 1960 and 1968 to 1977. This study was designed specifically to determine the characteristics and effects of delay in treatment. One hundred and forty-five patients were identified, fifty were then excluded because they had associated lesions, seven more because of inadequate information and five more who had posterior fossa haematomas. The remaining eighty-three patients with pure supratentorial extradural haematomas formed the basis of the study. During the first decade studied there were twenty-seven patients and during the second, fifty-six patients. Mortality was much lower during the second decade (8.9%) than in the earlier period (33%). Morbidity was also lower during the later period. Delay (the interval between the first recorded deterioration in conscious level and operation) longer than two hours led to a worse outcome. In the later period delay in hospital was less than in the earlier decade, the mean delays being 1.4 and 8 hours respectively. For both periods combined 41% of patients had a mean total delay of more than 1.9 hours and all either died or had a poor outcome. Progressively worse outcomes correlated with progressively longer mean delays culminating in the longest mean delay (15.7 hours) in the fourteen patients who died. The authors concluded that earlier diagnosis and treatment were the most important factors in reducing mortality and morbidity. Also, diagnosis could often be made clinically so that delay for investigation was not good practice in all cases.

Galbraith (78) dealt with misdiagnosis and delay during a period (1963-1974) which preceded and partly overlapped the second decade of Mendelow's study. He considered all types of post-traumatic intracranial haematoma as one group. Eleven of fifty-one patients who developed such lesions were first diagnosed at post-mortem. Although ten of these patients had a skull fracture, six had been misdiagnosed as strokes and five as drunks. These patients had been admitted for observation to a local teaching hospital. During the same period three hundred and seven patients

with haematomas had been admitted to the regional neurosurgical unit. More than one third of these patients had been deteriorating for over twelve hours in the referring hospital prior to transfer. Forty-eight of these one hundred and eleven patients were mislabelled as drunk, twenty-seven were misdiagnosed as strokes and in thirty-six no explanation for the deterioration was recognised. Altogether therefore, of one hundred and twenty-two patients with post-traumatic haematoma, fifty-three were misdiagnosed as drunk, thirty-three were mislabelled as strokes and in thirty-six no diagnosis was apparently made. Skull fractures were present in 77%, 88% and 69% of these groups respectively. Mortality was higher among patients in whom delay occurred (two to three times as high). As we saw in the epidemiological section of this study, doctors are not very good at accurately assessing alcohol intake (80), while alcohol consumption is a common accompaniment of head injury (77, 79, 80). To facilitate correct diagnosis and avoid undue delay, blood alcohol levels should be measured. If the blood level is less than 200 mg% and the patients conscious level is depressed, then alcohol is not responsible. On the other hand if the level is greater than 200mg% and the patients conscious level is depressed, then alcohol may well be responsible, but it would be foolish to assume that it was. The other clue to diagnosis missed in the above patients was the presence of a skull fracture which is exceedingly uncommon in patients who have suffered a genuine stroke. A fracture in such a patient should always indicate that a complication of their head injury has occurred. Delay in treatment of haematomas has also been shown to be an important cause of preventable mortality by other authors (21, 190, 191).

The number of operated cases of uncomplicated extradural haematoma at the Central Middlesex Hospital between 1947 and 1950 was nine, and during the same period the number of unoperated cases known to the district coroner was ten (264). No significant difference was apparent between the two groups in regard to age. However, the mean time from injury to death or operation was thirty-seven hours in the hospital cases and twenty-one hours in the coroners cases. In two of the four illustrative coroners cases,

delay in diagnosis had occurred in hospital, as it did in at least one of the seven illustrative hospital cases. The authors concluded that the main reason for the continuing high mortality was delay in diagnosis as a result of lack of appreciation of the natural history of the condition.

Although discussed separately, the above factors a-f show a varying interrelationship. Older patients are more likely to be rendered unconscious initially and less likely to be conscious throughout (225, 228). This would tend to worsen prognosis. Similarly posterior fossa haematomas, which have a worse prognosis are commoner in the elderly (225) whereas frontal lesions which have a better prognosis are commoner in young patients (223, 225, 253). Intradural lesions, which again attract a bad prognosis, are more common in older patients (229, 249). Intradural lesions also lead to more rapid evolution which is associated with an increased mortality (225). Children on the other hand show a slower evolution (228, 248). Frontal haematomas are commoner in young adults and children (223, 225, 253), develop more slowly (211, 212, 225, 239, 253) and less often produce unconsciousness (225).

Referring back to the table at the beginning of this section (Table 2.17), there seems to have been a welcome lessening in mortality in more recent series. However, no series has reached the "reasonable mortality" suggested by Hooper (212). The latter hundred patients in Jamieson and Yelland's series (225) had a mortality of 9.4% compared with 26% for the first sixty-one. All these patients, however, were operated on and the possibility of patients dying without operation is not dealt with by these authors. Also their lower mortality might be attributed to a relatively young group of patients. Balanced against this was a higher than average proportion with intradural lesions and a high proportion of patients with posterior fossa lesions, both associated with an adverse prognosis. Jonker and Oosterhuis's (249) relatively high mortality occurred against a background of large numbers operated on early and an older age-distribution, but a lower proportion with intradural lesions. Kvarnes and Trumpy (226) had a

lower mortality than Jonker and Oosterhuis with a similar distribution of ages and a higher proportion of intradural lesions, but almost half as many cases due to road traffic accidents. The lowest surgical mortality occurred in Heiskanen's series (248) and was associated with a lower than average incidence of traffic accidents and a high incidence of falls and assaults, as well as probably the lowest incidence of verified intradural lesions. The low mortality in the series reported by Phonprasert et al (229) occurred in a group of patients with an average age of 28.6 years (Heiskanen's average was 32.5 years) and three quarters of the patients were under thirty-one years. Cordobes et al (224) on the other hand, had a relatively older group of patients and a higher mortality, as well as the highest proportion due to road traffic accidents and the highest proportion unconscious at operation. In general, series with a lower incidence of lucid interval had the lowest mortality (225, 226, 248). Conversely, series with the highest incidence of lucid intervals had the highest mortality (211, 249).

2.4 SUBDURAL HAEMATOMA:

In contradistinction to extradural haematoma, subdural haematoma following head injury is usually caused by bleeding from surface veins lying over the convexity of the cerebral hemispheres close to the large venous sinuses (152, 170, 194, 265-269). Rarely, subdural haematoma occurs in the posterior fossa (270-274) interhemispheric fissure (269, 270, 275, 276, 277) or in the subtemporal area (270, 278). In a post-mortem study of one hundred and two cases, Vance (279) found subdural haematomas due to rupture of surface cerebral arteries in six of ten cases subjected to histological examination. Drake (280) reported subdural haematoma due to bleeding from a torn cortical artery over the surface of the brain in eleven of one hundred cases of subdural haematoma. However, Echlin et al (267) reported only six cases due to arterial bleeding among their three hundred cases of all types of subdural haematoma, but excluded subdural haematoma due to ruptured aneurysm or tumour. McKissock et al (281) excluded cases secondary to rupture of a vascular anomaly as did Talalla and Morin (282). The latter, in addition, excluded subdural haematoma due to rupture of an intracerebral haematoma into the subdural space, as well as clots complicating anticoagulant therapy or bleeding diatheses. In the discussion of this paper, Raaf maintained that acute subdural haematoma generally resulted from rupture of a cortical artery. McLaurin and Tutor (283) considered that venous bleeding alone rarely caused signs of cerebral compression in the first twenty-four hours, believing associated parenchymal brain injury was responsible for the clinical picture.

Two cases of acute subdural haematoma arising from arterial rupture and demonstrated pre-operatively by angiography were described by Danziger and Bloch (284). One case was the result of penetrating injury (gunshot wound) while the other resulted from severe blunt head injury. The former produced an interhemispheric subdural haematoma in association with a traumatic aneurysm of a callosomarginal artery. In the latter case a convexity haematoma arose from a tear in the posterior temporal branch of the middle

cerebral artery. Bergstrom and Hemmingsson (265) reported two cases of subdural haematoma of arterial origin. These arose from cortical aneurysms of leptomeningeal arterial anastomoses. In both instances the aneurysm was demonstrated pre-operatively by angiography and their natural history resembled that of subdural haematoma of venous origin. Displacement of the meninges at the time of injury causing erosion of the vessel and formation of a false aneurysm was believed by the authors to be responsible. Hoff and Gauger (268) described four cases of subdural haematoma of arterial origin, all with an acute onset and a skull fracture. In the first case bleeding arose from an artery within a dense fibrotic scar underlying an old fracture, in the second, bleeding arose from the middle meningeal artery associated with a dural laceration and a temporal fracture, in the third, bleeding came from dural vessels adjacent to a temporal fracture, and finally, in the fourth case, bleeding from the basilar artery was associated with an extensive basal and occipital fracture. These authors concluded that in elderly patients, the dura was often firmly attached to the skull, predisposing such patients to tears of the dural vessels when they sustain a skull fracture (cases 2 and 3, who were 77 and 84 years old respectively). Similarly, adherence of the dura due to prior injury or operation decreased the mobility of the brain and subsequent trauma caused tears of vessels around and within such adhesions (case 1, 69 years old). Finally, in severe head injury with extensive fracturing of the skull, large intracranial arteries are likely to be damaged (case 4, 29 years old).

Five further examples of acute subdural haematoma due to arterial bleeding have been described by O'Brien et al (285). The youngest patient was aged fifty-seven years and three more were aged seventy-five or more. One patient had polycythaemia rubra vera, one had had a chromophobe adenoma removed several years earlier and one had suffered a severe closed head injury two years previously. In each case bleeding arose from a surface cortical artery without aneurysm, vascular malformation, significant atheroma or arteritis, or previous adhesions. In four of the five cases histological examination revealed that bleeding originated at the site of

avulsion of a small arterial twig from a cortical artery. The junctions of such arterial twigs were considered by the authors to be inherently weak and therefore more likely to rupture when any stress was applied. Most recently Shenkin (286) reported that 62% of thirty-nine consecutive cases of acute subdural haematoma were due to arterial bleeding, only 26% were venous in origin, 7.7% resulted from cerebral contusions and 5% from acute bleeds into chronic subdural haematomas. The source of arterial bleeding was in each case a cortical artery.

Subdural haematoma complicating anticoagulant therapy has often been reported. Thus one of the hundred cases of acute subdural haematoma described by VanderArk (287) developed spontaneously in a patient receiving anticoagulant therapy. Similarly two of one hundred and fourteen cases of chronic subdural haematoma were receiving anticoagulants (288) as were two of twenty-one cases described by Dronfield et al (289). In the twenty years between 1959 and 1978 in Leiden, forty-six (22%) of two hundred and twelve cases of subdural haematoma of all types were receiving anticoagulant therapy (290). Subdural haematoma in patients receiving anticoagulants was associated with a higher mortality, a higher incidence of bilateral lesions, a lower incidence of definite traumatic episodes, an acute/subacute presentation and prolonged prothrombin times. For patients over forty years old, the risk of developing a subdural haematoma was twenty-six times as high in women and seven times as high in men receiving anticoagulant therapy as in people of the same age not receiving such treatment. For both sexes and for all patients over forty years, the incidence of subdural haematoma in patients on anticoagulants was 1/2000 patient years.

Leonard et al (291) discussed three cases of subdural haematoma occurring in patients undergoing haemodialysis, when presumably brain shrinkage as well as relatively incoagulable blood were of aetiological significance. Diagnosis in this group was difficult because of the resemblance of the clinical picture to the dialysis disequilibrium syndrome; two patients were diagnosed at

post-mortem. McClelland and Ramirez-Lassepas (272) described one case of spontaneous posterior fossa subdural haematoma in a patient taking anticoagulants, whilst Raggio et al (273) discussed a case of post-traumatic subdural haematoma in the posterior fossa occurring in a haemophiliac. Rice (292) recently reported a case of acute subdural haematoma, after a head injury sustained during a rugby match, in a patient with Von Willebrand's disease. Two cases of intracranial subdural haematoma following spinal anaesthesia and occurring in patients without apparent predispositions have been reported (293). Reuck et al (294) reported a series of eighty-three cases of chronic subdural haematoma. Seventy-three of these were pure, five involved invasion by malignant lymphoma and five more were associated with inflammation.

Although most often associated with direct injury to the head, subdural haematoma may occur as a result of indirect trauma as in the case described by Amacher and Li (295). Guthkelch (296) has described several cases of subdural haematoma, often bilateral, occurring in battered babies and attributed some of these to violent shaking of the child. Seventeen cases of acute interhemispheric subdural haematoma due to severe shaking and occurring in battered babies were described by Zimmerman et al (297). Subdural haematoma following whiplash injury has been reported by Ommaya and Yarnell (298), who concluded that the impact data showed a value slightly less than that predicted to cause cerebral concussion by head rotation. Waldman et al (299) reported a case of right subdural haematoma following an assault producing a left zygomatic fracture. Subdural haematoma occurring in a young boxer and arising after sparring alone was reported by Cruikshank et al (300).

The physiopathogenesis of subdural haematoma has been discussed and reviewed by Blue (266), Kaufman and Handel (301), Jamieson and Yelland (271) and Potter and Fruin (302), while an experimental model has been described by Glover and Labadie (303, 304). The latter two authors reached four conclusions in regard to chronic subdural haematoma:

- a) The composition and volume of the clot are critical variables,
- b) Plasma fibrin provides the matrix shape of the lesions,
- c) Breakdown of red blood cells, leucocytes, haemoglobin and other solid blood elements induces neo-membrane formation and contributes to subsequent growth,
- d) Inflammatory mechanisms appear to be essential while cerebrospinal fluid plays no discernible role in the process.

Gennarelli and Thibault (170) have detailed the biomechanics of acute subdural haematoma using an experimental method designed to impart angular acceleration to the head and negate the effects of impact damage. All of the monkeys who developed subdural haematoma had bleeding from ruptured parasagittal bridging veins. The subdural haematoma overlaid these ruptured veins and its size was dependent on the number of ruptured veins. Haematomas were usually bilateral, although much larger on one side, frontally predominant and often extended into the interhemispheric fissure. Death was due to massively increased intracranial pressure and a resultant marked decrease in cerebral perfusion. Three types of injury were delivered, first a low angular acceleration applied for a short time (less than 5 milliseconds) produced a mixture of acute subdural haematoma and cerebral concussion. Second, a low angular acceleration applied for longer than 5 milliseconds produced diffuse brain injury. Finally, a high angular acceleration for longer than 5 milliseconds produced acute subdural haemorrhage. The results of their experiments adequately explain the known findings in human head injury, particularly the well recognised fact that subdural haematoma is more common after falls and assaults than as a result of traffic accidents, whereas diffuse brain injury is more common after traffic accidents and less commonly results from falls or assaults.

Conventionally, subdural haematoma has been classified as acute, subacute or chronic. Unfortunately there has been no general agreement as to how these terms should be applied until recently. Some authors divide patients into these categories on a purely temporal basis (264, 266, 267, 271, 281, 286, 287, 305-315) while others make these distinctions on the basis of membranes being present (294, 309, 310, 316, 317, 318) or on the appearance of the haematoma fluid (271, 288). Although definition on a temporal basis is most common, time intervals vary, thus Blue (266) defined an acute subdural haematoma as one diagnosed in the first twenty-four hours, as did Britt and Hamilton (305), Cooper et al (319), Richards and Hoff (313), Seelig et al (169) and Vicario et al (320). Cantore et al (306) and James and Turner (264) settled on forty-eight hours; Fell et al (307), Hernesniemi (308), Jamieson and Yelland (271), McKissock et al (281), McLaurin and Tutor (283), Ohaegbulam (312), Rosenorn and Gjerris (315), Rosenbluth et al (214), Talalla and Morin (282), Szamosi (321) and VanderArk (287) utilised seventy-two hours, Echlin et al (267) up to one week and May (311) and Galbraith (78) upto two weeks. Such lack of uniformity necessarily makes comparison of different series more difficult.

2.4.1 INCIDENCE:

The relative incidence of extradural and subdural haematoma has altered over the last forty or fifty years. In Australia in 1935 the ratio of uncomplicated extradural haematoma to subdural haematoma found at routine autopsy was 3:1 (247). However by 1963 this ratio had reversed to 1:30 and most of this change was due to an increase in the frequency of severe acceleration-deceleration injury. During the same period there was a sixfold rise in the number of subdural haematomas revealed at post-mortem. The same author in conjunction with others has reported series of patients with surgically treated extradural haematomas (225) and subdural haematomas (271) occurring during an eleven year period, and found subdural lesions were about three times as common as extradural lesions. In the British series discussed in the epidemiological section of this thesis, the ratio of subdural haematoma to

extradural haematoma varied as follows: 1:1 (43), 2:1 (42), 2.2:1 (56), 2.6:1 (29, 57). These series are arranged approximately in chronological order and cover the period 1945 (42) to 1977 (57). Generally, the trend is to an increase in the relative incidence of subdural haematoma, a confirmation of Jamieson's findings. If the incidence of extradural haematoma in the United Kingdom is 0.2% of head injury admissions (250) then the incidence of subdural haematoma is probably about 0.5% of admissions or 1.4/100,000 population.

As with head injuries in general, reliable epidemiological data regarding the incidence of subdural haematoma is scant, most authors failing to relate the number of patients with such lesions to the total number of patients at risk. Echlin et al (267) recorded subdural haematoma in 1% of all head injury admissions in New York from 1940 to 1951. The relative incidence of the different types was: acute 3.1/1000 admissions (acute = upto one week), subacute 3.4/1000 admissions (subacute = one to three weeks) and chronic 2.5/1000 admissions (chronic = more than three weeks). On the West Coast between 1966 and 1969 the incidence of acute lesions (diagnosed upto seventy-two hours) was 22/1000 admissions (282). Allowing for the differences in definition and assuming a similar absolute incidence of head injury and similar admission policies, this represents about an elevenfold increase in the incidence of acute lesions in a twenty year period. In 1977 Dublin et al (251) reported a series of two hundred head-injured patients who underwent computerised tomography. These were drawn from a group of six hundred and twenty patients with head injury seen in the emergency room. Forty-one patients (6.6%) had subdural haematomas and in a third these were bilateral. Fell et al (307) presented a series of one hundred and forty-four cases of acute subdural haematoma (i.e., treated with 72 hours) occurring in Texas during a twelve year period up to 1972 but omitted population details. However, when replying to a letter prompted by their article, Fell (322) stated that the catchment population was 1.5 million and that their hospital was the primary treatment centre for this entire population. This would indicate an incidence of 0.8/100,000

population per year for acute subdural haematoma or a little over half the estimated United Kingdom incidence for all cases of subdural haematomas as adduced above.

In Italy, acute supratentorial subdural haematoma occurred in forty-nine patients during the three years 1974 to 1976 (306). These cases represented 15% of all cases of head injury submitted to angiography, but the total number of patients with head injury occurring during the same period was not stated, nor was the population at risk. The ratio of subdural haematoma to extradural haematoma from this study was about 2:1. Patient selection also operated in the study by El Gindi et al (323) who described two thousand patients with head injury admitted for more than three days between 1970 and 1975. Subdural haematoma occurred in 4.3% (0.35% acute, 3.9% chronic) and the ratio of subdural to extradural haematoma was 4.3.

A Finnish study provides a more accurate guide to incidence (318). Sixty-four cases of chronic subdural haematoma occurring during a seven year period were identified. Twenty-four cases (38%) were first diagnosed at post-mortem. The incidence was 1.7/100,000 per year, which is more than the estimated incidence of all types of subdural haematoma in the United Kingdom. Furthermore the authors concluded that this figure was an underestimate since not all deaths were submitted to post-mortem examination and not all subdural haematomas identified at post-mortem came to their knowledge. In one British study 40% of cases of chronic subdural haematomas first came to light after death (264); while a later study of a selected population from Nottingham also found about 40% (eight of twenty-one cases) were first recognised after death (289). From the same city as Fogelholm et al (264), Hernesniemi (308) reported a series of patients with acute subdural haematoma (i.e., diagnosed or operated on within seventy-two hours) presenting in the five years 1973 to 1977. This series of one hundred and thirty-six cases comprised 6.1% of head injuries treated in the neurosurgical department. The first year of this study overlapped with the last year of Fogelholm's study (318) and assuming the same population, the incidence of acute

subdural haematoma was 5.1/100,000 population per year. This figure is almost certainly an overestimate since some patients would have been secondary referrals, also the population of Helsinki is likely to have altered between 1969 and 1977 when Hernesniemi's study ended. Nevertheless it would seem likely from a consideration of these two studies that acute subdural haematoma is more common than chronic subdural haematoma.

Jamieson and Yelland (271) employed the same temporal definition of acute subdural haematoma as Hernesniemi and of four hundred and sixty-six patients with sufficiently accurate details, and excluding patients with subdural hygroma, two hundred and sixty-five (57%) had acute, one hundred and fifty-five (33%) had subacute and forty-six (10%) had chronic subdural haematomas. Thus acute lesions were more than five times as common as chronic lesions in Australia from 1956 to 1967. However this series included only operated cases. Five per cent of all head injuries admitted during the eleven year period developed subdural haematomas (birth injuries and spontaneous lesions were excluded). Also during the period of the study the incidence of subdural haematoma had increased and the lesions had become more complicated. In London between 1940 and 1958, three hundred and eighty-nine patients with subdural haematoma were admitted to one unit (281), between 1940 and 1959 the same authors and others, reported a series of one hundred and twenty-five cases of extradural haematoma which represented 3% of head injury admissions (228). Thus the ratio of subdural to extradural lesions was about 3:1. However, although employing the same temporal definition as Jamieson and Yelland, the proportions due to acute (21%), subacute (23%) and chronic subdural haematomas (56%) were very different. The British series included nine unoperated cases and covered an earlier period than the Australian series, which included only operated cases. The change in the relative incidence of acute, subacute and chronic lesions between the two series, in conjunction with the proportion of each series showing associated lesions (4.4% - 281, 24% - 271), supports Jamieson's view that more complicated types of subdural haematoma are becoming more common, such types being more often acute. In Chicago during a period which

followed shortly after the British study and coincided with the early and middle portion of the Australian series the relative incidence of the different lesions using the same temporal definitions was: acute 27%, subacute 51% and chronic 22% (314). These results are transitional between the British and Australian series, showing a shift towards more acute lesions. Echlin et al (267), for the years 1940 to 1951 which preceded and overlapped with the British study, found the following proportions: acute (upto forty-eight hours) 17%, subacute (three to twenty-one days) 58% and chronic (more than twenty-one days) 25%, similar figures to those of Rosenbluth et al (314).

Most recently Wintzen and Tijssen (290) have described subdural haematoma occurring in patients receiving anticoagulant therapy. However, they also included details of all cases of subdural haematoma occurring between 1959 and 1978 inclusive in a circumscribed area of Holland. Population figures were also furnished for 1978. All cases were hospital admissions and diagnosis had been made by CT scan, at operation or at post-mortem. The authors believed that virtually all cases of subdural haematoma occurring in the catchment population during the study period were included. The estimated incidence for all types of subdural haematoma was 2.8/100,000 per year, (4.4/100,000 for males and 1.2/100,000 for females). For acute (diagnosed up to seventy-two hours), subacute (diagnosed four to fourteen days) and chronic lesions (diagnosed after more than two weeks) in patients forty years old or more, the proportions were 48%, 25% and 27% respectively. The incidence rates in this age group for the same lesions were: acute 3/100,000 per year, subacute 1.5/100,000 per year and chronic 1.7/100,000 per year.

Summarizing, therefore, we can say that the incidence of all types of subdural haematoma is between 2 and 3/100,000 and that about half this incidence is accounted for by acute lesions. Subacute and chronic lesions each account for about a quarter of the total incidence. In the Hospital In-patient Enquiry: England and Wales for 1977 (69) an estimated eleven hundred and seventy patients

had diagnoses included in rubrics N852 (subarachnoid, subdural and extradural haemorrhage following injury) and N853 (other and unspecified intracranial haemorrhage following injury). This was an incidence of 2.4/100,000, so that the true incidence of subdural haemorrhage was probably slightly less than 2/100,000.

2.4.2. AGE AND SEX:

Conomy et al (324) in their ten year retrospective study, identified one hundred and fifteen adults with subdural haematomas and determined that there were two age peaks. The first occurred between the second and fourth decades with a median point at twenty-five years, and the second between the sixth and eighth decades with a median point at sixty-five years. Generally younger patients had a higher proportion of more acute types of haematoma. In an earlier series comprising three hundred and eighty-nine patients with all types of lesion, numbers peaked in 50-59 year olds and more than two-thirds were fifty years or older (281). The male/female ratio was 2:1. Twelve years after the latter series was published, a larger series of five hundred and fifty-three cases of all types was reported (271). The male/female ratio in this series was 3.7 and only 40% were aged fifty-one years or older. In patients under twenty years and over sixty years the male/female ratio was lower at 2.8 and 2.1 respectively, while in 21-30 year olds it was 6 and in 31-40 year olds it was 5.4, in 41-50 year olds it was again 6 and in 51-60 year olds was 4.8. Eighteen per cent of all patients were in the fifth decade and 17% in the sixth decade. For the twenty years upto and including 1978 in Holland 26% of all cases of subdural haematoma were under forty years with a male/female ratio of 4, and the ratio in patients over thirty-nine was 3.4 (290). Eight per cent of patients were aged 40-49 years, 17% were aged 50-59 years, 21% were aged 60-69 years and 28% were seventy years or older. In the latter four age groups the male/female ratios were 1.8, 4.1, 4 and 3.2.

Ingraham and Matson (325) reported a series of ninety-eight cases of subdural haematoma in children upto two years old,

occurring in the six years upto mid-1943. Twenty-eight cases were known to have suffered birth injury, although the authors thought this an underestimate. Not unexpectedly therefore, the highest incidence occurred in the first six months of life, two thirds of patients being in this group and a further one fifth were aged seven to twelve months. A later paper from Canada identified two hundred and thirty-five cases among four thousand, four hundred and sixty-five children under fifteen years, who were admitted because of head injury during a period of a little over eight years upto 1962 (134). Only pure haematomas were included, 59% were under six months old and 27% were aged six months to two years. Birth trauma accounted for 6% of all four thousand, four hundred and sixty-five injuries, although the number of subdural haematomas caused by this means was not stated. McKissock et al (281) reported 5.9% of their patients were aged 0-9 years whereas Jamieson and Yelland (271) reported 5.8% were 0-10 years old and the latter excluded cases due to birth injury.

a) Acute Lesions:

1. Diagnosed Within Seventy-Two Hours:

In one large British series describing all types of subdural haematoma, 21% of patients had an acute subdural haematoma (281). Numbers steadily increased with age and the highest number occurred in patients over seventy years of age. 57% were fifty years or older and the male/female ratio was 1.7 compared with a ratio of 2 for all types of haematoma. However, in Jamieson and Yelland's series (271) of five hundred and fifty-three surgically treated cases, 57% of the four hundred and sixty-six patients with accurate details (and excluding fifty-five fluid collections) had acute subdural haematomas. The peak incidence occurred in the fourth decade. A report from America coinciding with the first eleven years of the series reported by McKissock et al (281), revealed 17% of three hundred cases of subdural haematoma were operated on in the first forty-eight hours (267). Overlapping the latter part of the British series of McKissock et al, McLaurin and Tutor (283) reported

64% of ninety cases of acute subdural haematoma were over thirty years old. In Edinburgh for the decade 1960 - 1969, two hundred and sixty-nine cases of acute subdural haematoma were recorded (326). There was a steady increase in numbers with age with a minor peak among 10-29 year olds and a major peak in 60-69 year olds. The male/female ratio was 3.3, 17% were aged 0-19 years, 19% were aged 20-39 years, 26% were aged 40-59 years and 35% were aged 60-79 years. Towards the latter end of the period studied in Edinburgh, Talalla and Morin (282) in Los Angeles found eighty of one hundred consecutive cases of acute subdural haematoma were male. The age range was eighteen months to eighty-nine years and a peak occurred in the fifth and sixth decades. Fell et al (307) reported a series of one hundred and forty-four patients operated within seventy-two hours and occurring in the twelve years upto 1972. 36% were aged 21-40 years, 33% were aged 41-60 years and 9% were over sixty. Rosenorn and Gjerris (315) discussed a series of 'uncomplicated' acute and subacute subdural haematomas occurring during the ten years upto March 1974. One hundred and twelve patients had an acute subdural haematoma, 70% of these were aged 15-64 years and 24% were over sixty-four years old, the male/female ratio was 2.2. The median age of one hundred patients described by VanderArk (287) was fifty-one years with a range from six weeks to eighty-two years and a male/female ratio of 3.3. In Helsinki during the five years 1973 to 1977, one hundred and thirty-six patients with acute subdural haematomas were diagnosed or operated on within seventy-two hours of injury (308). The male/female ratio of this series was 4.3 and the average age was 44.6 years with a range from eight years to seventy-seven years. Shenkin (286) reported a series of thirty-nine consecutive cases with acute subdural haematoma occurring since 1976 in Philadelphia. The male/female ratio was 3.3 and the average age was 53.8 years. Patients in whom the haematoma was due to arterial bleeding had a higher average age (56.4 years) than those in whom the bleeding was of venous origin (46.8 years).

2. Diagnosed Within Twenty-Four Hours:

Richards and Hoff (313) shortened the qualifying period for the diagnosis of acute subdural haematoma to twenty-four hours. Their one hundred patients were collected retrospectively during the years 1963 to 1971. The male/female ratio was 6.1, the average age was forty-seven years and the age range two to eighty years. One hundred and thirty of the one hundred and forty-four patients described by Fell et al (307) and referred to above were operated on within twenty-four hours. In the earlier series of McLaurin and Tutor (283) seventy-four patients (82%) were operated on within twenty-four hours. Twenty-four hours was the stipulated period to diagnosis for forty-two patients presenting between 1969 and 1976 (305). The male/female ratio of this group was 2.5, the mean age thirty-six years and the age range two to eighty-three years. Cooper et al (319) reported a series of fifty patients with acute unilateral subdural haematomas occurring in the early 1970's. They excluded patients who also had extradural haematomas. The average time from admission to operation was 5.9 hours. The mean age of the patients was 48.6 years and only nine were female (male/female ratio 4.6). Seelig et al (169) discussed eighty-two comatose patients with acute subdural haematoma resulting from non-missile head injury, but excluded patients less than two years old. These patients were admitted during a period of a little over seven years upto February, 1980. The mean time from injury to operation was less than six hours in seventy-six cases and indeterminate in the remaining six patients. The male/female ratio was 3.1 and the mean age forty-one years. In a series of eighty-five patients with all types of subdural haematoma discussed by Vicario et al (320) the exact definition of acute subdural haematoma is not clear, but was probably confined to those patients diagnosed within twenty-four hours. Of the total number of patients, fifty-seven had a history of or external evidence of head injury and three-quarters of these had acute subdural haematomas. The age range of the whole series was fourteen to eighty-nine years.

b) Subacute Lesions:

A steady increase in incidence with increasing age occurred

in the British series described by McKissock et al (281) which covered the years 1940 to 1958. Of ninety-one cases of subacute subdural haematoma (presenting in 4-20 days), 12% were aged 20-39 years, 26% were aged 40-59 years, 22% were aged 60-69 years and 36% were seventy years or more. These ninety-one patients represented 23% of the total series of all types of subdural haematoma. The male/female ratio was 1.2. By contrast during the period 1940 to 1951 in New York, one hundred and seventy-five (58%) of three hundred cases of subdural haematoma of all types were operated on between the third and twenty-second day after injury (267). In Australia between 1956 and 1967 one third of a series of four hundred and sixty-six patients with all types of haematoma, for whom accurate timings were available and excluding fluid collections, were operated on within three to twenty days (271). The peak incidence for this type of lesion was in the fifth decade. Utilising the same temporal definition as McKissock et al and Jamieson and Yelland, but excluding complicated lesions, Rosenorn and Gjerris (315) discussed thirty-seven cases of subacute subdural haematoma presenting in Denmark from 1965 to 1974. The male/female ratio was 5.2, none were aged less than fifteen years while 35% were over sixty-four years old. Ohaegbulam (312) reporting from Nigeria also defined subacute cases as those presenting within four to twenty-one days. This series covered the six years upto the end of 1979 and identified seventy-three cases of subacute subdural haematoma and fifty-nine cases of chronic subdural haematoma. For all one hundred and thirty-two patients the sex ratio was 5:1 and the age range one to seventy-nine years (age unknown in 8 cases), 29% were aged 20-29 years, 21% were 30-39 years and only 17% were fifty or more years old.

c) Chronic Lesions:

Chronic subdural haematoma occurred in 56% of the series described by McKissock et al (281) compared with only 10% of Jamieson and Yelland's series (271) and 25% of the series described by Echlin et al (267). In the British series, 10% of cases of chronic subdural haematoma were under ten years old, about a third

were aged 50-59 years and 63% were fifty years or older. The male/female ratio was 3. Most patients in Jamieson and Yelland's series were in the seventh decade. Overlapping with the last ten years of the series of McKissock et al and all of the series of Jamieson and Yelland, Hirakawa et al (309) discussed three hundred and nine adult cases of chronic subdural haematoma occurring in Tokyo between 1948 and 1972. A further forty-two patients aged 0-4 years presented during the same period of twenty-four years. For those patients over four years the male/female ratio was 10.4. Among males, the highest number occurred in 50-54 year olds and in females among 45-49 year olds. 45% of males and 56% of females were fifty years old or more. The series of one hundred and fourteen cases reported by Cameron (288) also overlapped with the latter part of the series of McKissock et al and the whole of the series of Jamieson and Yelland. Cameron found a male/female ratio of 2.6 and the average age of his patients was fifty-six years. In this series definition on a temporal basis was abandoned owing to lack of the necessary details. Instead the operative finding of a black fluid surface collection over one or both cerebral hemispheres was taken to indicate that the lesion was a chronic subdural haematoma. During a similar time period, Fogelholm and Waltimo (1967-1973) (318) and Fogelholm, Heiskanen and Waltimo (1966-1973) (317) reported on chronic subdural haematoma occurring in Helsinki. Membrane formation was the basis of the definition in both series. The age-specific incidence rose from 0.25/100,000 in 20-29 year old men to 15.7/100,000 in 70-79 year olds and from 0.76/100,000 in 30-39 year old females to 4.2/100,000 in 70-79 year old females and 7.8/100,000 in women over seventy-nine years (318). Treating both sexes together the incidence rose from 0.13/100,000 in 20-29 year olds to 7.4/100,000 in 70-79 year olds before falling to 6.4/100,000 in those eighty years old or more. The male/female ratio was 2.4 overall, but 7.5 in 50-59 year olds. Nearly three-quarters of all patients were fifty years or older. In a larger study of one-hundred and nine cases, incidence in both sexes peaked at 60-69 years with the preceding decade only a little less (317). The male/female ratio was approximately 8. The interval to operation lengthened as the patients age increased. A small selected series

reported by Dronfield et al (289) had a male/female ratio of 2 and an average age of sixty-six years. In Africa, chronic subdural haematoma is rare in patients under thirty and is 4.5 times as common in males as females, patients having a mean age of fifty-six years. (310). In Belgium among all ages chronic subdural haematoma occurred most often in the first year of life (45%) with a peak at four months and a further peak at sixty-five years (294). In adults over fifteen years, 28% were over sixty years and 40% over fifty years. The age and sex distribution of a series from Nigeria has already been referred to (312).

2.4.3 PREDISPOSITIONS:

The prevalence of epilepsy in the general population is, as we have already seen, approximately 0.5% (76). Conomy et al (324) found patients with epilepsy were over-represented in the younger age groups with subdural haematoma. Pre-existing epilepsy was reported in 3.6% of the patients with all types of subdural haematoma described by McKissock et al (281) while Cameron (288) reported the higher proportion of 5.3%.

The association between subdural haematoma and anticoagulant therapy, bleeding diatheses and spinal anaesthesia has been referred to in the introduction to this section (272, 273, 287-293).

Recent alcohol consumption occurred in 22% of adult A&E patients with head injury and in a significantly higher proportion of patients admitted to surgical wards and of patients admitted to neurosurgical units (17). Corrigan (159) has described an alcoholic head trauma triad consisting of fatty liver, pneumonia and subdural haematoma. In patients with acute subdural haematoma alcohol is often associated with the precipitating cause, especially falls (319). Acute alcohol intoxication was noted on admission in 38% of the cases of acute subdural haematoma discussed by Britt and Hamilton (305). Of one hundred and thirty-six patients with acute subdural haematoma, twenty-nine were chronic alcoholics and a

further thirty-nine smelt of alcohol on admission (308). Similarly in VanderArk's series (287) 52% were chronic alcoholics. In their review of the management of head injury, Bruce et al (196) pointed out that chronic subdural haematoma was particularly common in chronic alcoholics. Conomy et al (324) stated that acute alcohol intoxication and chronic alcoholism were more than twice as common in younger patients with subdural haematoma. In Africa seventeen of sixty-three patients with subdural haematoma were habitual drinkers (327) and in Finland more than half of patients with chronic subdural haematoma were alcoholics (318) whereas in Manchester only 4% were alcoholics (288). At least 21% of the series reported by Shenkin (286) were alcoholics.

The relationship between subdural haematoma and social class has rarely been studied. In Finland, Fogelholm and Waltimo (318) found chronic subdural haematoma was more than twice as common in social class IV as predicted. More than two-thirds of Umerah's (327) patients came from lower income groups and many of the patients described by Cooper et al (319) were derelicts who had often sustained their injuries from falls occurring when they were under the influence of alcohol.

2.4.4. CAUSES:

McKissock et al (281) divided causes into those causing loss of consciousness (major) and those not associated with loss of consciousness (minor). In addition, four cases of chronic subdural haematoma were attributed to coughing and in ninety-five cases the cause was unknown. In acute cases, major causes were more common than minor, while in chronic cases when the cause was known this was more often minor, in subacute cases major and minor causes were equally common. In Jamieson and Yelland's series (271), road traffic accidents were the commonest single cause accounting for 35% of cases in both sexes, peaking in the second decade in males and females with a further peak at 60-70 years in females. They were also the commonest cause of complicated haematomas and fluid collections. Domestic accidents accounted for about a quarter of

cases and most often caused simple haematomas. These accidents were commoner in older patients, particularly women, and in the very young of both sexes. Industrial accidents and brawls each accounted for about 6%, were commonest in middle-aged males and were often associated with complicated haematomas. Sports accidents mostly occurred in young males aged between 10-30 years and were equally likely to cause simple or complicated haematomas.

a) Acute Lesions:

Not all publications delineated the different types of causes. Acute haematomas were most often due to road traffic accidents in Jamieson and Yelland's paper (271). Thus 64% of haematomas due to road traffic accidents developed within forty-eight hours and only 8% after two weeks, whereas only 41% of haematomas caused by domestic accidents developed within forty-eight hours. These latter, in conjunction with 'other causes', showed the slowest rate of development. Haematomas due to sport, industrial accidents and brawls were intermediate in their rate of evolution. Generally, complicated subdural haematomas presented early, 72% within forty-eight hours and only 6% later than one week, whilst 28% of simple haematomas presented within forty-eight hours and 55% later than one week. 44% of patients with cerebral contusions and subdural haematomas presented within forty-eight hours and 42% of those with fluid collections presented within forty-eight hours. The rate of evolution also varied with age. Under the age of thirty the majority presented within forty-eight hours and over thirty years the majority presented more slowly. VanderArk (287) also reported patients with acute subdural haematoma diagnosed within seventy-two hours, road traffic accidents accounted for 30%, falls 20%, assaults 15% and unknown causes 34%. Using the same temporal definition, Hernesniemi (308) found falls (51%), road traffic accidents (37%) and other causes (12%) responsible in his one hundred and thirty-six patients. In a recent series, Shenkin (286) reported 41% were due to falls, 18% due to assaults, only 2.6% were due to road traffic accidents and in 38% the cause was unknown.

In a series limiting its definition to twenty-four hours, falls (37%), road traffic accidents (29%), assaults (11%) and unknown causes (23%) were responsible in one hundred patients (313). Most of the patients described by Cooper et al (319) were injured under unknown circumstances although most were thought to be due to falls or blows to the head, few being the result of road traffic accidents. However, in Britt and Hamilton's series (305) road traffic accidents accounted for 60% of forty-two cases and falls only 17%. Seelig et al (169) reported 55% were due to road traffic accidents, while Vicario et al (320) found falls and direct blows (53%) more common than road traffic accidents (47%).

b) Subacute Lesions:

In McKissock et al's series (281), major trauma accounted for 46%, minor trauma for 44% and in the remainder the cause was unknown. In the series reported by Jamieson and Yelland (271), one third of all cases were subacute, these were rarely complicated lesions, most being simple haematomas or haematomas associated with cerebral contusions or fluid collections. Accordingly, traffic accidents were less common as a cause of this type of haematoma than of acute subdural haematoma, whereas domestic accidents were relatively more common. More than three-quarters of one hundred and thirty-two cases of subacute and chronic subdural haematomas described by Ohaegbulam (312) were due to road traffic accidents, 14% were due to blunt blows, 7.6% to falls and 1.5% to stab wounds.

c) Chronic Lesions:

Chronic subdural haematomas are generally the result of less severe injury, only 24% were due to major trauma in one series (281). A history of trauma was found in 89% of another series, of these, 47% were the result of road traffic accidents, 35% occurred during 'ordinary life', 10% were due to sporting accidents, 3% industrial accidents and 5% other causes (309). One fifth of Cameron's (288) one hundred and fourteen patients had no identifiable head injury, sneezing, coughing and heavy lifting each

accounted for one case, 2% were due to falls to the sitting position and 63% were due to direct head injury. In a Finnish study, a history of trauma was more common among surgically treated patients than among cases found at post-mortem (318). In another article 71% of one hundred and nine operated cases had a history of trauma (317). Dronfield et al (289) reported a small selected series of twenty-one patients admitted to medical wards during a five year period. Less than half had a history of trauma and in none of these had head injury led to initial loss of consciousness. In a similar study from Africa, five of eleven patients had definite evidence of trauma (310).

In children falls are the commonest cause of injury leading to subdural haematoma (134, 328) whilst non-accidental injury (328) and birth trauma (325, 328) are also relatively common causes.

2.4.5 SYMPTOMS:

a) Acute Lesions:

A persisting alteration in the conscious level following injury characterises this type of lesion and consequently limits the symptoms since such patients are unable to complain. Only two out of fifty patients operated on within forty-eight hours became sufficiently mentally clear to walk and to answer questions in the series reported by Echlin et al (267). Both these patients were confused. McKissock et al (281) reported the following symptoms in their eighty-two patients with acute subdural haematoma, all of whom had an altered conscious level, headache (11%), confusion (12%), vomiting (24%), weakness (21%) dysphasia (6.1%).

b) Subacute Lesions:

Of ninety-one cases of subacute subdural haematoma described by McKissock et al (281), eighty (88%) had an alteration of consciousness. The following symptoms were recorded: headache (53%), confusion (42%), vomiting (31%), weakness (19%), dysphasia

(7.7%) and vertigo (4.4%). Headache was also the commonest symptom in alert patients described by Echlin et al (267). In the mixed series of subacute and chronic subdural haematomas discussed by Ohaegbulam (312) 42% complained of headache, 19% experienced fits and 8.3% suffered mental changes.

c) Chronic Lesions:

Potter and Fruin (302) in their review of chronic subdural haematoma, commented on the non-specific nature of the symptoms and signs, particularly in the elderly, and suggested this condition has replaced syphilis as the great imitator of the common neurological disorders in the elderly. In an earlier paper, McKissock et al (281) also remarked on the non-specific nature of the symptoms. In this latter series, two hundred and sixteen patients had chronic subdural haematoma with the following symptomatology: headache (81%), alteration in consciousness (48%), confusion (38%), vomiting (30%), weakness (22%), visual symptoms (13%), dysphasia (6.5%) and vertigo (5.6%). Alteration of the conscious level often fluctuant, mental deterioration and headaches were all common in those patients described by Echlin et al (267). Many of their cases were initially admitted as psychiatric patients. An ataxic gait occurred in 27% of the series reported by Hirakawa et al (309), 24% had psychiatric symptoms including loss of recent memory, lessened ability for calculation and personality changes, the latter being particularly common in older patients. 9% had convulsions, whereas headache and vomiting occurred in nearly all patients and disturbances of the conscious level occurred in 22%, rather less than in McKissock's series. The onset and course of events was very variable, although in nearly half a slow progression occurred. In a similar way to Hirakawa et al, Cameron (288) classified patients into three groups according to their presenting symptoms: hemiparesis, personality change and raised intracranial pressure. Most of their patients presented with the characteristics of only one group. Fluctuations in symptoms and signs occurred in 24% and personality or intellectual changes in 30%. Headache was experienced by 43%, being the only symptom in 5%. However two-thirds of another series

suffered headache and this was commoner in younger patients, whereas mental changes were significantly more common in older patients (317). Headache was a prominent symptom in 52% of the patients discussed by Dronfield et al (289) and all had an impaired conscious level. Mental changes (45%) occurred prominently in those patients described by Levin (310), as did headache (64%).

In children with chronic subdural haematoma, 28% had experienced vomiting but neither this nor headache were significant of any particular pathology (134). In infants with acute subdural haematoma, vomiting occurred in 16% in one series (328). In the same series, convulsions occurred in 80% of newborns and 68% of infants. An earlier series included all cases of subdural haematoma in infants, convulsions occurred in 56%, vomiting in half and irritability in almost a half (325). However, nearly as many children also had a concomitant infection so interpretation of such symptoms is very difficult. Further symptomatology can be gleaned from the above articles, as well as from papers by Cohen and Neal (329), Gutierrez and Raimondi (330) and McOsker (331), which give details of specific cases.

2.4.6 SIGNS:

a) Acute Lesions:

i. Conscious Level:

All of the patients in McKissock's series (281) had an alteration of consciousness on admission, no patients were alert, 27% were drowsy, 43% were stuporose and 30% comatose. In the series reported by Echlin et al (267) all patients with subdural haematoma operated on within forty-eight hours had an altered conscious level from the time of injury, 90% remaining stuporose or semi-stuporose, only 4% were subsequently able to walk or answer questions. A complete or partial lucid interval occurred in 18% of the patients described by McLaurin and Tutor (283), the remaining patients all continued in coma until operation.

In Harris's series (326) a lucid interval occurred in 12%, and 15% of the total number of patients were conscious on admission. Only one of Talalla and Morin's (282) one hundred patients was alert on admission, 36% were arouseable and showed purposeful movements, 18% were unarouseable to verbal stimuli and showed decerebrate postures either spontaneously or in response to pain, the remaining 45% were unarouseable, flaccid and areflexic. Fell et al (307) did not, unfortunately, describe their patients conscious level. Rosenorn and Gjerris (315) found 20% of their one hundred and twelve patients were awake or slightly somnolent, the remainder being stuporose or comatose. VanderArk (287) reported a series of one hundred patients presenting between 1971 and 1973, none were alert pre-operatively, 20% were stuporose, 49% were in semi-coma and 31% were comatose. In Helsinki from 1973 to 1977, 13% of one hundred and thirty-six patients were alert on admission, 12% responded verbally to painful stimuli, 12% responded purposefully to pain, 49% had a stereotyped response to pain and 14% exhibited no response to pain (308). A lucid interval occurred in 39% with roughly half deteriorating prior to admission and half subsequently. 54% were unconscious throughout and 7.4% were conscious when the decision to operate was made. A lucid interval was commoner in older patients, younger patients were more often unconscious from the outset than older ones. In the small series described by Shenkin (286) a lucid interval definitely occurred in 41% and varied from thirty minutes to forty-eight hours.

When the diagnosis of acute subdural haematoma is limited to those cases diagnosed within twenty-four hours, a severely depressed conscious level is the rule (169, 313, 319) although Britt and Hamilton (305) did record that one of forty-two patients was awake when first seen in the emergency room. In Richards and Hoff's (313) one hundred cases, none were alert pre-operatively, 79% were stuporose i.e., arouseable by vigorous and repeated stimuli, 21% were unresponsive and unarouseable. Similarly all fifty patients described by Cooper et al (319) were unarouseable, exhibiting some decerebrate movements only or being flaccid and areflexic. None of

the eighty-two patients described by Seelig et al (169) were able to speak intelligibly or obey verbal commands at the time of their initial neurosurgical evaluation and 47% were decerebrate or flaccid.

ii. Hemiplegia:

44% of acute cases described by McKissock et al (281) exhibited motor signs on admission. All of the cases operated on within forty-eight hours described by Echlin et al (267) had neurological signs, usually progressive and suggestive of a focal lesion. Motor signs occurred in 51% of a series from Ohio (283). Such signs were either a definite hemiparesis or extensor spasms occurring spontaneously or after stimulation. In 75% with motor signs, the signs were contralateral, in 16% ipsilateral and in the remainder decerebration was present. Harris (326) reported hemiplegia occurred in only 26% of his two hundred and sixty-nine patients, while Talalla and Morin (282) reported 34% had a hemiparesis and this was ipsilateral in 38%. VanderArk (287) also reported an incidence of 34% for hemiparesis, contralateral in all cases. In cases of acute subdural haematoma in children upto five years, hemiparesis occurred in 42% of infants and all toddlers (328).

Richards and Hoff (313) confined their patients to those diagnosed within twenty-four hours and 26% had a hemiplegia. Only fifteen of forty-two patients described by Britt and Hamilton (305) had an accurate motor assessment, two thirds had a contralateral and one third an ipsilateral hemiplegia.

iii. Pupillary Abnormality:

Unequal pupils occurred in 30% of all types of subdural haematoma in the series of McKissock et al (281) but in 57% of cases of acute subdural haematoma. Most often the dilated pupil was ipsilateral and in the cases of bilateral subdural haematoma was usually bigger on the side with the larger haematoma. McLaurin and Tutor (283) found 78% had a pupillary abnormality and in 56% of these ipsilateral dilatation was present, in 17% contralateral

dilatation, 4.3% had constricted pupils and the remainder had bilaterally fixed, dilated pupils.

Unilateral pupillary dilatation occurred in 24% of another series of acute subdural haematomas and bilateral fixed dilated pupils in a further 28% (326). A further series, reporting a period equal to the final three to four years of Harris's paper, recorded unilateral dilatation in 53%, 23% of these being contralateral (282). A Danish series covering the period 1965 to 1974 found normal pupils in 18%, unequal but reacting pupils in 12%, a unilateral fixed dilated pupil in 30% and bilateral fixed dilated pupils in 36% (315). In a further American series for the years 1971 to 1973, 50% had a unilateral fixed dilated pupil and 22% bilateral fixed dilated pupils, while the remainder had reactive or constricted pupils (287). In only one case was a dilated pupil at some stage contralateral to the subdural haematoma.

Anisocoria was present in 57% of patients described by Richards and Hoff (313), while a further 13% had bilateral, fixed dilated pupils. 48% of the series reported by Cooper et al (319) had bilateral fixed pupils. Britt and Hamilton (305) recorded anisocoria in 55%, most being non-reactive. In 91% with anisocoria, the dilated pupil was ipsilateral to the haematoma. A further 24% had equal, fixed and dilated pupils. Bilaterally absent pupillary light reflexes were present in 45% of cases reported by Seelig et al (169). In children upto five years old with acute subdural haematoma unequal pupils occurred in 11%, but in all patients over two years (328).

iv. Other Neurological Signs:

Papilloedema is uncommon, particularly in acute lesions (267) when only 1% had this sign (281). The latter authors recorded dysphasia in 6.1%, when it was always associated with lesions of the dominant hemisphere. Convulsions occurred in 6.1% of cases described by the same authors, but in 18% of another series (283) and 17% of another (313).

North-Coombes et al (332) and Caplan and Zervas (333) discussed case reports of patients with decerebration and subdural haematoma. One would obviously expect this condition to be commonest in cases of acute subdural haematoma, particularly those diagnosed within twenty-four hours. McLaurin and Tutor (283) recorded an incidence of 6.7% among their ninety patients, but felt this was an underestimate. In Harris's series (326) 14% were comatose and decerebrate, 4.8% were comatose and flaccid/decerebrate and altogether 42% were flaccid/decerebrate. VanderArk (287) reported 4% became decorticate in response to pain and 18% decerebrate. The frequency of decerebration in patients with acute subdural haematoma diagnosed within twenty-four hours was higher, thus 34% (313), 74% (decorticate, decerebrate or flaccid - 319), 21% (305), 47% (decerebrate or flaccid - 169).

v. Other Signs:

Classically raised intracranial pressure is associated with bradycardia and systemic hypertension, accompanied by headache, vomiting and papilloedema. Approximately half of those patients with a rapid downhill course in the first forty-eight hours had a rise in blood pressure in one series (267). In McLaurin and Tutor's series (283) only eight patients (8.9%) showed an elevation of more than 20mm Hg in systolic blood pressure, while fourteen (16%) showed a decrease in pulse of more than six/minute. The authors did not consider that a change in the vital signs contributed to the decision to operate in any one patient. 17% of cases in another series had combined bradycardia and systemic hypertension, although a total of 29% of patients had a pulse rate below 70/minute (282). A typical Cushing's response occurred in 8.1% of a combined series of acute and subacute subdural haematomas (315). VanderArk (287) reported hypertension in 26% and bradycardia in 13%. However, all patients with either bradycardia or tachycardia had evidence of coning whereas only a quarter of such patients had systemic hypertension. 41% developed a new arrhythmia.

Respiratory abnormalities may also occur as a result of head injury. 11% of the patients described by McLaurin and Tutor (283) showed a variation of more than 4/minute in their respiratory rate, although the reason for this change was not usually their head injury. In patients with a more acute subdural haematoma 18% were apnoeic pre-operatively and none of them survived (319). In Britt and Hamilton's series (305) 12% had respiratory abnormalities - two fifths had slow irregular respiration, two fifths were apnoeic and a fifth had Cheyne-Stokes respiration. It is likely that in many patients immediate or early intubation was carried out, either as management for their head injury or for other injuries, and to avoid the superadded cerebral insult of hypoxia. Such action would necessarily affect observation of respiratory changes.

b) Subacute Lesions:

i. Conscious Level:

Alteration of consciousness occurred in 88% of the ninety-one cases of subacute subdural haematoma described by McKissock et al (281). Some degree of drowsiness and disorientation was present in 74% of cases operated on three to twenty-two days after injury in the series of Echlin et al (267). Pre-operatively the great majority showed a deteriorating conscious level, often fluctuating, sometimes hastened by convulsions, and usually ending in semistupor, stupor or coma. In Rosenorn and Gjerris series (315) 76% were awake or slightly somnolent and the remainder stuporose or comatose. Ohaegbulam (312) reported a mixed series of one hundred and thirty-two cases (73 subacute and 59 chronic) and 57% had impaired consciousness at the time of diagnosis. Pre-operatively 21% of patients with subacute lesions were alert, 32% were drowsy, 47% were stuporose and 1.4% were comatose. Of the whole series 80% had experienced an initial loss of consciousness.

ii. Hemiplegia:

Motor signs occurred in 37% of the patients described by

McKissock et al (281). Progressive unilateral motor weakness occurred in one-fifth of patients operated on the seventh to the twenty-second day in one large series (267). A hemiparesis or hemiplegia was found in 64% of all patients with subacute or chronic subdural haematoma described by Ohaegbulam (312).

iii. Pupillary Abnormality:

This finding occurred in 27% of cases of subacute subdural haematoma compared with 57% of acute cases (281). Most often the dilated pupil was ipsilateral to a unilateral haematoma or to the larger of bilateral haematomas. Echlin et al (267) reported that a widely dilated pupil was most often ipsilateral but that mild dilation was of no value. Rosenorn and Gjerris (315) reported normal pupils in 57%, unequal but reacting pupils in 19%, a unilateral fixed dilated pupil in 5.4% and bilateral fixed dilated pupils in 19%. Ohaegbulam (312) recorded an oculomotor palsy in 37% of his patients with subacute subdural haematoma.

iv. Other Neurological Signs:

Hemianopia was reported to occur in 4.4% of patients, papilloedema in 15% and confusion or memory loss in 21% (281). The same authors reported dysphasia, always associated with a dominant hemisphere lesion, in 12%. Echlin et al (267) also reported a low incidence of papilloedema, homonymous hemianopia and hemisensory loss, whilst Rosenorn and Gjerris (315) did not discuss these aspects. 13% of all cases had papilloedema and 8.3% had mental changes in the mixed series described by Ohaegbulam (312). Two cases of subacute subdural haematoma with transtentorial herniation have been described by Keane (334). Both cases showed oculomotor palsies with pupillary sparing. Devereaux et al (335) described two cases of subacute subdural haematoma with internuclear ophthalmoplegia caused by transtentorial herniation.

v. Other Signs:

One third of all types of subdural haematoma were associated with a rise in blood pressure in the series reported by Echlin et al (267). Patients with subacute lesions who developed a systolic pressure greater than 170 mm Hg also had an elevated cerebro-spinal fluid pressure, although the converse was not true. Rosenorn and Gjerris (315) described a mixed series, one hundred and twelve patients having acute and thirty-seven having subacute subdural haematomas. Overall only 8.1% showed a typical Cushing response. Changes in the rate and rhythm of respiration and pulse were not studied by the above workers in their cases of subacute subdural haematoma.

c) Chronic Lesions:

i. Conscious Level:

Among a group of two hundred and sixteen patients with chronic subdural haematoma, 59% had an alteration of consciousness (281). Confusion and/or memory loss occurred in 27% of the same group of patients. In another series, only 11% were fully alert and orientated, the majority showed mental deterioration for weeks or months with a variable degree of disorientation and confusion, often progressing to fluctuating drowsiness (267). Many were initially admitted to psychiatric wards or were thought to have arteriosclerotic encephalopathy or brain tumour. The large series of three hundred and nine cases described by Hirakawa et al (309) covered the years 1948 to 1972 and overlapped with both the series mentioned earlier in this paragraph. A disturbance of consciousness occurred in 22% while loss of recent memory, decreased ability to calculate and personality changes occurred in 24%, these latter changes became prominent as age increased. 45% of patients had no initial loss of consciousness, 21% were initially unconscious for upto five minutes, 15% for five to thirty minutes, 3.9% for thirty to sixty minutes, 8.1% for one to six hours and 7% for more than six hours. Like Echlin et al, Cameron (288) reported that many of his cases had been incorrectly diagnosed as having cerebrovascular disease, psychiatric disorder or brain tumours. 13% of patients

were comatose at the time of operation compared with 4.6% of the series reported by Fogelholm et al (317). This latter series reported somnolence, confusion and memory loss in 53% and these changes were significantly more common in the older age groups. The same authors also reported that mental deterioration occurred in 39%, although did not specify what form this took. Such mental deterioration was not significantly more common in any particular age group. In a small selected series reported by Dronfield et al (289) all twenty-one patients had a disturbed conscious level on admission. In 14% a fluctuating conscious level was noted subsequently, a third showed a gradual or rapid deterioration, 10% a gradual improvement and in the remaining 43% the conscious level remained unchanged. A similar, although smaller study from Africa also reported that all patients had a depressed conscious level on admission - 45% showed changes in behaviour, 40% were drowsy but rouseable and 15% were unrouseable (310). Also from Africa, Ohaegbulam (312) reported 71% were alert prior to operation, 17% were drowsy, 10% were stuporose and only one patient (1.7%) was comatose.

ii. Hemiplegia:

Motor signs were present in 41% of patients with chronic subdural haematoma compared to 37% with subacute subdural haematoma and 44% with acute subdural haematoma in one large series covering the years 1940 to 1958 (281). Paresis when present, was contralateral to the haematoma in 59%, ipsilateral in 29% and lesions were bilateral in 12%. Echlin et al (267) reported progressive unilateral motor weakness in 42% of their cases of chronic subdural haematoma. Hirakawa et al (309) grouped motor and sensory disturbances together and found these occurred in 56%, being more common in older patients. Cameron (288) reported an incidence very similar to McKissock and to Echlin - i.e., 39%. Such weakness was contralateral in 60%, ipsilateral in 40%. In a series from Finland 48% showed hemiparesis or reflex asymmetry and these findings became significantly commoner as age increased, occurring in 62% of patients aged 60-79 years (317). Nearly two-thirds of the

cases discussed by Dronfield et al (289) had hemiparesis at some stage. In four of these thirteen patients bilateral haematomas were present and only one of the remaining nine patients with a unilateral haematoma had ipsilateral hemiparesis. Levin and Gelfand (310) recorded hemiparesis in six of their eleven patients, ipsilateral in only one, while one patient had bilateral haematomas.

iii. Pupillary Abnormality:

Anisocoria was present in only one fifth of patients described by McKissock et al (281) which was only about half the incidence in acute and subacute cases described by the same authors. Echlin et al (267) reported pupillary inequality occurred in 48% of cases of subdural haematoma of all types. They did not differentiate the occurrence of this finding in the different types of lesions. In the large series from Tokyo only 5% had anisocoria, which was nearly twice as common in the presence of bilateral haematomas (309). Cameron (288) reported an identical incidence to the Japanese series and the dilated pupil was always ipsilateral. Both series dealing with medical patients, who developed subdural haematoma, reported a higher incidence of pupillary inequality than either Cameron or Hirakawa et al, i.e., 9.5% (289) and 18% (310).

iv. Other Neurological Signs:

Papilloedema (22%), dysphasia (11%), hemianopia (3.2%) and facial weakness (3.2%) were also recorded in the cases described by McKissock et al (281). Homonymous field defects were a particularly accurate localising sign; dysphasia was always associated with a dominant hemisphere lesion. Echlin et al (267) reported a similar spectrum of signs as occurring but did not quantitate them. However they found a catatonic posture, tremor and an unsteady or shuffling gait particularly in chronic cases. Papilloedema was particularly common in the series from Tokyo, 53% having this sign (309). An ataxic gait (27%), ocular palsy (13%) and aphasia (7%) were less common. Ataxic gaits were commoner in patients with bilateral lesions and ocular palsies and aphasia were both commoner in

patients with left-sided lesions. Cameron (288) reported papilloedema in one fifth of his patients, a very similar result to McKissock. Approximately a third had papilloedema and hemiparesis, a third papilloedema and coma and a third papilloedema and headache or vomiting. Fogelholm et al (317) also found a similar incidence of papilloedema (26%) which was significantly commoner in younger patients (53% aged 20-39 years, 16% aged 60-79 years). Dronfield et al (289) recorded papilloedema in 14% and homonymous hemianopia in 9.5% of their patients. In a similar but smaller group of patients Levin and Gelfand (310) recorded papilloedema in 9.1%. A mixed series of cases of subacute and chronic subdural haematoma showed papilloedema in 13% (312).

v. Other Signs:

Most cases of chronic subdural haematoma who developed systemic hypertension in one American series also had an elevated cerebro-spinal fluid pressure, although the reverse was not the case (267). Overall less than a third had systemic hypertension. Levin and Gelfand (310) related blood pressure and pulse to cerebro-spinal fluid pressure. Only one of the four cases with raised cerebro-spinal fluid pressure had a raised blood pressure. Additionally only one patient had systemic hypertension combined with a bradycardia and this patients cerebro-sinal fluid pressure was not elevated. A patient with bilateral papilloedema had a systolic blood pressure of 60 mm Hg and a pulse rate of 100/minute.

The admirable paper by Jamieson and Yelland (271) discussed five hundred and fifty-three cases of subdural haematoma of all types and described various neurological abnormalities. These latter, however, were not presented in relation to the conventional temporal categories of haematoma, so will be briefly outlined here. Five trends in the conscious level were described, 13% were initially knocked out, recovered consciousness and became unconscious again prior to operation. Most of these patients (62%) had complicated lesions and were of an acute type. 13% of patients were initially knocked out and subsequently became and remained

conscious until operation. Most of these patients (54%) had simple haematomas which were generally not acute. However 32% had complicated lesions. 16% of the total number of patients were not initially knocked out but became unconscious, again most had simple lesions (63%) and only 26% had complicated lesions. 29% of patients were unconscious throughout and 70% had complicated lesions while 21% had simple haematomas. 29% were conscious throughout and 67% of these had simple haematomas, while 14% had complicated lesions and 17% had fluid collections. For the whole series, 80% of those with complicated haematomas and 70% of those with contusions were concussed compared with only 35% of those with simple haematomas and 38% of those with fluid collections. Similarly 80% with complicated haematomas were unconscious at operation compared with 42% with simple haematomas. These differences between the different types of haematoma were highly significant. Again, for the whole series, initial unconsciousness occurred in 55%, 13% had a classical lucid interval and most of these had complicated lesions.

Abnormality of one pupil occurred in 28% overall but in 40% of those operated on within twelve hours. Altogether nearly three quarters of patients with an abnormality of one pupil had acute lesions. Abnormality of both pupils occurred in 16% overall; virtually all were acute lesions and complicated haematomas. 70% of those with bilateral fixed dilated pupils had decerebrate rigidity. Hemiplegia occurred in two-fifths of all patients and half of these also had eye signs. This latter combination had double the mortality of hemiplegia with normal pupils. Decerebrate rigidity occurred in 16% of cases, nearly all complicated and 69% were operated on within twelve hours. About one sixth of patients with decerebrate rigidity were not initially knocked out and a similar proportion had a lucid interval. Decerebrate rigidity alone attracted a mortality of 89% and with fixed dilated pupils 95%. Aphasia (7.6%), field defects (0.7%) and other focal signs (2.5%) were also recorded. Epilepsy occurred in 11% and was most common in subacute cases, as was aphasia. Bradycardia occurred in 16% and systemic hypertension in 11%, 6% had both bradycardia and hypertension. These findings were commoner in acute lesions and in

patients with complicated haematomas.

d) Children:

Among ninety-eight children with all types of subdural haematoma, including those due to birth trauma, less than a third were either stuporose on admission or gave a history of periods when they could not be aroused by ordinary stimuli (325). In another general series, but excluding birth injuries, 37% were not knocked out initially, 25% were drowsy, irritable or confused on admission, 15% were unconscious throughout, 10% were initially knocked out and then remained conscious, 7% were not knocked out initially but became unconscious subsequently, 2% showed a lucid interval and 1% a wavering conscious level (134). Ingraham and Matson (325) reported some form of paralysis in 15% of their patients and hyperactive reflexes in two-thirds. Only 5% of children in the Canadian series had hemiplegia and hemiparesis (134). The latter authors recorded a single dilated pupil in 7% and bilaterally dilated pupils in 9% of their children with all types of subdural haematoma. Convulsions occurred in about 56% of the cases described by Ingraham and Matson (325) whereas Hendrick et al (134) reported that a third of their patients had convulsions.

In cases of acute subdural haematoma in children five years or less and including those due to birth injury, 68% of infants and all toddlers had an altered conscious level (328). Hemiparesis occurred in 42% of infants and all toddlers. Likewise unequal pupils were present in all patients over two years, but in only 11% of the whole series.

2.4.7 SKULL FRACTURE:

a) Acute Lesions:

In many cases and clearly for cogent reasons, not all patients have plain skull X-ray and the number having this investigation may well be less since the advent of computerised

tomography. For those patients diagnosed within seventy-two hours, a quarter did not have plain skull X-ray (281). Of those X-rayed, 55% had a fracture of the skull (associated with pineal displacement in 18% of those with fracture). A further 6.5% had pineal displacement but no skull fracture. In another series only two-fifths of patients operated on during the first forty-eight hours had skull X-ray, but 70% of these had a fracture (267). McLaurin and Tutor (283) reported two-thirds of their patients had skull X-ray and 51% of those X-rayed had a fracture. In 57% the skull fracture was ipsilateral to the haematoma and in the remainder was contralateral. Pineal shift was present in 10% of those X-rayed. In a large series including all types of haematoma from Australia only 48% had skull X-ray and 54% of those X-rayed had a skull fracture, but this was present in 80% of those with complicated haematomas, 80% of those with contusions and 70% with fluid collections who were X-rayed (271). Talalla and Morin (282) reported at least 55% of those X-rayed had a skull fracture.

For patients operated on within twenty-four hours, 60% of those X-rayed (88%) had a skull fracture (313). Pineal shift was evident in 8% of patients who had skull X-ray. All of the patients discussed by Britt and Hamilton (305) had skull X-ray. 24% had a unilateral fracture, ipsilateral to the haematoma in 40%. A further 4.8% had bilateral skull fractures. Seelig et al (169) did not report the incidence of skull fracture in their series but Vicario et al (320) reported that 41% of those X-rayed had a skull fracture.

Hendrick et al (134) recorded a depressed or linear skull fracture in 15% of children with all types of subdural haematoma. The likelihood of a child developing a traumatic subdural haematoma decreased with increasing age, while the association of skull fracture with subdural haematoma increased with increasing age. Depressed fractures were uncommon - only 11%. Often the subdural haematoma was contralateral to the fracture and only one of six patients with bilateral fractures had bilateral subdural haematomas, whereas a hundred and forty-three patients had bilateral haematomas. In an earlier study Ingraham and Matson (325) reported

11% of infants had skull fractures. They did not say how many had sutural diastasis. In acute cases in children upto five years old, 41% had skull fractures and diastasis was invariable in the newborn who constituted 19% of the series (328).

b) Subacute:

McKissock et al (281) reported that 11% of their cases of subacute haematomas did not have skull X-ray. 21% of those X-rayed had skull fracture alone, 2.5% had skull fracture and pineal displacement and 26% had pineal displacement alone. Echlin et al (267) reported a hundred and seventy-five cases operated on three to twenty-two days after injury, of whom 68% had skull X-rays. Skull fractures were present in 57% of those patients who were X-rayed. In his mixed series of patients with subacute and chronic subdural haematoma, Ohaegbulam (312) reported that skull fracture occurred in 15% of all patients.

c) Chronic Lesions:

Fewer of McKissock's patients with chronic subdural haematoma had skull fracture (6.1%) than did those with subacute (23%) or acute (55%) subdural haematoma (281). Pineal displacement alone however was nearly as common in chronic cases (23%) as in subacute cases (26%) and much commoner than in acute cases (6.5%). Pineal displacement with or without fracture occurred in 16% of acute cases, 28% of subacute and 23% of chronic cases. Fifty-five patients described by Echlin et al (267) were operated on more than thirty days after injury and a skull fracture was present in 40% of those X-rayed; only 36% had this investigation carried out. In a larger series reported by Hirakawa et al (309) 7% of the total number had skull fractures. Cameron (288) reported 82% had skull X-rays available for examination and of this proportion 6.5% had a skull fracture. In the selected series reported by Dronfield et al (289) nearly two-thirds had a skull X-ray but no patients had a fracture. One patient however did show pineal shift.

2.4.8 TYPES AND SITES OF LESIONS:

Jamieson and Yelland (271) recognised five types of lesions:-

- a) Simple haematomas - not associated with any surface contusion or laceration of the brain and consisting of liquid, clotted or altered blood with or without a membrane and of sufficient size to cause clinical deterioration.
- b) Complicated haematomas - collections of subdural blood overlying a cerebral laceration, identified at operation as being at least in part the cause of the haematoma. These included surface lacerations, lacerations with intracerebral haematoma and burst temporal lobes.
- c) Subdural fluid collection - accumulations of cerebro-spinal fluid, some bloodstained or xanthochromic and of sufficient size to cause deterioration or symptoms and signs. Synonyms - hygromas, hydromas, effusions or pachymeningitis serosa.
- d) Contusion and subdural haematoma - a significant cerebral contusion underlying a subdural haematoma but not contributing to it.
- e) Multiple lesions - e.g., complicated subdural haematoma on one side and a simple subdural haematoma on the other.

In two of their five hundred and fifty-three cases the type of lesion was not defined. Of the remainder 45% were simple, 41% complicated, 10% were fluid collections, 3.6% were combined subdural haematomas and contusions and 0.5% were multiple. Simple haematomas were most often due to mild injury and were mostly subacute or chronic. Complicated haematomas and fluid collections were due to serious traffic accidents or industrial accidents and were more often acute.

Of the two hundred and forty-nine simple haematomas 94% were over the convexity of the cerebral hemispheres, 4.4% were localised and 1.2% occurred in the posterior fossa. Overall 7.2% of simple haematomas were bilateral and were commoner in children. Complicated haematomas were often localised and sometimes associated with multiple lacerations when the mortality was higher. 8.5% had bilateral complicated subdural haematomas. Single lacerations occurred in about half and 56% were situated in the temporal pole, 23% in the frontal pole, 9.6% over the convexity and only 0.9% in the posterior fossa. Multiple lacerations when present averaged three per case and such patients were most often over thirty years old. 58% were situated in the temporal pole or over the convexity, 15% were frontal and temporal, 14% were frontal and over the convexity and 0.9% occurred in the posterior fossa. Fluid collections occurred over the convexity in 82%, in the posterior fossa in 15% and at the temporal pole in 3.6%. In 9.1% the fluid collections were bilateral.

Of patients suffering lateral trauma and not having an associated extradural haematoma or depressed fracture, significantly more cases of simple haematoma and hygroma were ipsilateral to the trauma compared to cases of complicated haematomas and contusions, which were themselves more often contralateral. Contrecoup injury occurred in 69% of two hundred and ninety-one cases of cerebral laceration and/or contusion in which the site of trauma was known. Significantly more patients with extradural haematomas had right-sided blows to the head. In patients with subdural haematomas associated with lacerations and contusions due to lateral trauma, more had right-sided blows, but the difference was not significant. Twenty patients had cerebral contusions and subdural haematomas, seven were multiple, one was bilateral and twelve were situated over the convexity (7 frontal, 5 temporal) and one over the cerebellum.

The intervals between injury and the development of haematomas varied with the type. 28% of simple haematomas developed within forty-eight hours compared with 72% of complicated lesions, 44% of lesions associated with cerebral contusions and 42% of

hygromas. 55% of simple haematomas developed later than one week compared with 6% of complicated haematomas. Frontal or temporal pole lesions developed fastest (mostly complicated lesions). Posterior fossa lesions were slower to develop and convexity lesions slowest of all. 36% of lesions that resulted from road traffic accidents presented within twelve hours, 64% within forty-eight hours and only 8% more than two weeks after injury. Haematomas resulting from domestic accidents were slowest to develop (41% less than 48 hours and 20% more than 2 weeks) and those resulting from sports, industrial accidents and assaults were intermediate. Simple haematomas developed more slowly and complicated haematomas more quickly than extradural haematomas. In most patients under thirty years haematomas developed more quickly, mostly within forty-eight hours and over thirty years lesions were slower to develop. Even with simple haematomas younger people presented more quickly.

For all five hundred and fifty-three cases, 2.5% occurred in the posterior fossa and 7.8% were bilateral. Bilateral collections were more common in hygromas (9.1%) and complicated lesions (8.5%) than in simple haematomas (7.2%) and those associated with cerebral contusions (5%). McKissock et al (281) reported bilateral lesions in 20%, being most common in acute cases (33%) and less common in subacute (20%) and chronic (16%) cases. Only 0.5% of McKissock's cases had posterior fossa haematomas and both were in patients with acute lesions. Echlin et al (267) stated that about 18% of subdural haematomas were bilateral and McLaurin and Tutor (283) reported that 16% of acute cases were bilateral. Also discussing acute cases Talalla and Murin (282) reported 55% on the right, 37% on the left and 8% bilateral. When the external site of injury could be determined in cases of unilateral lesions, forty-two were contralateral and fifty-nine ipsilateral to the clot. Of one hundred and one blows in seventy-four patients with unilateral clots, only nineteen blows were lateral, thirty-three were to the anterior quadrant of the head and forty-nine to the posterior quadrant of the head. In Harris's series (326) of two hundred and sixty-nine patients, one hundred and seventy died and 16% of these had bilateral subdural haematomas. Fell et al (307) also described

cases diagnosed within seventy-two hours and found bilateral lesions in 15%, although the proportion was much less for the latter six years of the study (7%) than for the first six years (21%). Rosenorn and Gjerris (315) had no cases of bilateral haematomas. VanderArk (287) like Jamieson and Yelland (271) and Talalla and Morin (282), found 8% of his acute cases had bilateral lesions.

For their more acute cases Richards and Hoff (313) reported bilateral lesions in 30% and 23% of all cases required resection of severe temporal lobe contusions. 61% of the seventy-four patients who died had cerebral lacerations at post-mortem, while 49% had necrotic frontal and temporal lobes. Nearly three-quarters had a subdural haematoma greater than 50 ml found at post-mortem.

In the thirty-years between 1948 and 1977 only twenty-three adult cases of subdural hygroma were treated at the Neurological Institute in Montreal (336). This contrasts with fifty-five cases occurring in an eleven year period and already referred to above (271). The former authors added two further cases to their series which had a male/female ratio of 4, an age range of 20-83 years and a mean age of fifty-three years. 64% resulted from road traffic accidents, 28% from domestic accidents and sport and assaults each accounted for 4%. 52% were bilateral compared with 9.1% in the Australian series. A fifth of lesions presented within forty-eight hours, two-fifths between two and fourteen days and two-fifths more than fourteen days after injury. All patients were X-rayed and 44% had a skull fracture. In 80% the fluid was xanthochromic, in 8% bloody and in 12% clear and colourless with an average volume of 57ml (range 8-150 mls). Gutierrez and Raimondi (330) described six cases of post-traumatic subdural effusions occurring in children aged ten weeks to four years. Four of the six had fallen from a bed, one had no history of trauma, and the sixth had a skull fracture, but it was not stated how the injury had occurred. Altogether four patients had a skull fracture. All six were readmitted 16-28 days after their initial presentation when the diagnosis was made. In three cases the fluid removed was bloody and in one xanthochromic.

Miles and Medlery (274) described two cases of subacute subdural haematoma occurring in the posterior fossa. These were the only cases of posterior fossa subdural haematoma occurring in four hundred and eighteen patients with subdural haematoma treated during a twenty-six year period. Both patients had occipital fractures, in each case on the side contralateral to the haematoma. None of the subacute cases described by Rosenorn and Gjerris (315) were bilateral, whereas McKissock et al (281) reported 20% were bilateral and none were situated in the posterior fossa. In another series 15% of cases of subacute (73 patients) and chronic (59 patients) subdural haematoma were bilateral (312).

Bilateral lesions occurred in 16% of chronic cases described by McKissock et al (281) and none occurred in the posterior fossa. In the large series reported by Hirakawa et al (309) the incidence of bilateral lesions was also 16%. In unilateral cases, left-sided lesions were more common (54%). Bilateral lesions were twice as likely to be accompanied by unequal pupils and more likely to cause ataxia, but less likely to cause aphasia or fits. In 30% of these chronic cases the haematoma covered the whole hemisphere, in 25% the fronto-parieto-temporal area, 24% the fronto-parietal area and 21% other areas. Overall 88% had a frontal component, 93% a parietal component and hardly any an occipital component. Cameron (288) reported bilateral lesions in 11% and Fogelholm et al (317) in 7.3%. In two small selected series, bilateral lesions occurred in 38% (289) and 9.1% (310). Umerah and Singarayar (327) also reported a series from Africa and included sixty-three cases of all types and about two-thirds of their cases were chronic. Bilateral lesions occurred in 21% of the whole series. El Gindi et al (323) reported the higher incidence of 51% with bilateral lesions.

In the series of ninety-eight cases occurring in children upto two years old and including those due to birth injury, no less than 79% were bilateral (325). Subdural hygromas accounted for 9.1% of bilateral cases and 14% of unilateral cases. Bilateral lesions occurred in 61% of another childrens series and 10% were situated in

the posterior fossa (217).

2.4.9. ASSOCIATED INTRACRANIAL LESIONS:

Jamieson and Yelland (271) recorded associated intracranial lesions requiring operation in 24% of their series of five hundred and fifty-three cases. These were made up of seventy-six associated extradural haematomas (51% of associated lesions) (thirty-one were ipsilateral to the subdural lesion and forty-five were contralateral) and seventy-three associated intracerebral haematomas unrelated to the cerebral laceration responsible for the subdural lesion. These one hundred and forty-nine associated lesions occurred in one hundred and thirty-four patients, fifteen had both extradural and intracerebral haematomas. In those patients with only an extradural haematoma as the associated lesion, roughly half had simple subdural haematomas and half had complicated lesions. The maximal incidence for these types was in the second decade. When an intracerebral haematoma was the only associated lesion, maximal incidence was in the fifth decade and the distribution of this type paralleled the age-distribution of complicated subdural haematoma. In addition 20% had single cerebral lacerations and 20% had multiple lacerations with an average of three per patient.

In acute cases described by McKissock et al (281) 17% had associated lesions - one contralateral extradural haematoma, ten cases of (temporal) intracerebral haematomas and two cases with posterior fossa haematomas in addition to their supratentorial haematoma. Temporal intracerebral clots occurred in 8% of cases operated within forty-eight hours described by Echlin et al (267) while at least 38% had a brain laceration noted at operation. McLaurin and Tutor (283) reported associated intracranial haematomas in fifteen patients (17%), made up of four cases with extradural haematoma and eleven with intracerebral clots. Most of the latter were situated in the temporal lobe. 63% of the patients discussed by Harris (326) died, and at post-mortem 7.1% had extradural haematomas, 54% had contusions and lacerations, 11% had intracerebral haematomas, bilateral in a sixth, 1.2% had

intraventricular haematomas and 3.5% had contre-coup lesions. Brain swelling was present in 42%. Talalla and Morin (282) recorded intratemporal haematomas in 8% of their cases, 6% had brain lacerations and 65% had visible contusions at operation. Of the latter sixty patients in the series reported by Fell et al (307) a quarter had cortical contusions, 22% had intracerebral haematomas, 6.7% had extradural haematomas, 1.7% had a cortical laceration and 1.7% had an intraventricular haematoma. The cases described by Rosenorn and Gjerris (315) were selected, and excluded patients with associated intracranial lesions. Hernesniemi (308) reported that sixty-seven (49%) of his patients had an intracerebral haematoma or contused brain or both. Such intracerebral lesions were removed at operation in thirty-eight cases (57%). Extradural haematomas occurred in 6.6% overall. Cantore et al (306) limited their definition of acute subdural haematoma to those requiring operation within forty-eight hours and identified forty-nine supratentorial lesions in the years 1974 to 1976. One quarter of their cases were hemisphere lesions and the remainder were localised. Cerebral lacerations were present in 46% with localised lesions and 58% with hemisphere lesions.

Richards and Hoff (313) discussed one hundred patients with acute haematoma coming to operation within twenty-four hours. 57% showed haemorrhagic, swollen cortex at operation and in 23% temporal lobe contusions necessitated resection of pulped brain. The overall mortality was 74%. Cortical petechial perivascular haemorrhages occurred in 89% of those who died, leptomeningeal haemorrhage in 72%, an inadequately treated or reaccumulated subdural haematoma greater than 50 ml in 73%, cortical lacerations in 61%, haemorrhagic necrosis of the frontal and temporal lobes in 49%, intraventricular haemorrhage in 16% and intratemporal haematomas in 3%. At operation 62% of another series had cerebral contusions, 7.1% had intracerebral haematomas and 2.4% had cortical lacerations (305). Only ten of the twenty-three patients who died had post-mortem examinations and seven of these had extensive contusions, the same number had massive cerebral oedema, six had pontine haemorrhages and five had uncatal herniation. Seelig et al (169) reported 65% of their cases had

associated intracerebral contusions or haematomas.

Only two of the twenty-five cases of traumatic subdural hygroma described by St. John and Dila (336) had associated lesions - one chronic subdural haematoma on the opposite side and one extradural haematoma. Radiological studies revealed ventricular enlargement in 44% of the cases. All six childhood cases of subdural effusion reported by Gutierrez and Raimondi (328) had bilateral lesions. None had associated lesions at the time of their second admission, however, one patient had a radiologically diagnosed temporal lobe contusion during her first admission but not during her second admission.

The cases of subdural haematoma of all types occurring in childhood and discussed by Hendrick et al (134) were all "pure" and constituted 5.3% of head injury admissions. Cases of cerebral contusion and laceration, pulping of the brain and intracerebral haemorrhage were counted as a separate group and constituted 3.2% of admissions. Of this latter group 30% had intracerebral haemorrhage and the remainder had parenchymal injuries of the frontal (36%), parietal (35%), temporal (15%) and occipital lobes (4%) (217). Cerebellar damage occurred in 10% of those with parenchymal injuries, when it was usually associated with severe supratentorial damage.

Intracerebral haematomas occurred in 3.3% of the ninety-one subacute lesions described by McKissock et al (281). No indication of associated intracranial lesions was given by Echlin et al (267) in their subacute cases, while Rosenorn and Gjerris (315) considered only cases of pure subacute haematoma, Ohaegbulam (312) also did not discuss associated lesions.

None of the two hundred and sixteen cases of chronic subdural haematoma discussed by McKissock et al (281) had associated intracranial lesions. Echlin et al (267), Hirakawa et al (309) and Cameron (288) did not discuss such findings. Fogelholm and Waltime (318) mentioned cerebral contusion as the cause of death in three of

twenty-four cases of chronic subdural haematoma diagnosed at post-mortem. None of the other authors discussing chronic subdural haematoma and referred to already, mention associated lesions. This fact is not unexpected since one would expect few, if any, cases to have more than (old) contusions, otherwise their natural history would be different. The same would hold for cases of subacute haematoma.

Associated extracranial lesions are rarely discussed by any of the authors referred to above. In traumatised patients, who will largely have acute subdural bleeding, they can be expected to be relatively common when they will contribute to the cause of death. Hypoxia and hypovolaemia as a result of such injuries will also have effects on the primary brain injury. Richards and Hoff (313) recorded other major injuries in 13% of their patients with acute subdural haematoma. 9% were in shock when first examined, 3% had major thoracic or abdominal injuries and 2% had obstructed airways. Two of forty-two patients described by Britt and Hamilton (305) were intubated on arrival at the emergency room because of multiple trauma, whilst a total of thirteen patients (25%) had sustained significant abdominal, thoracic or limb trauma.

2.4.10 MORTALITY:

In cases diagnosed within twenty-four hours and arranging series in chronological order, the surgical mortality rate varies thus: 73% (283), 63% (271), 48% (307), 77% of all cases (308), 75% (313), 90% (319), 55% (305), 57% (169). By the same means but including patients diagnosed upto seventy-two hours, the surgical mortality rates of different series were: 51% (281) (54% of all cases), 63% (283), 68% (282), 59% (314), 55% (271), 63% (326), 45% (307), 73% (315) (pure cases only), 47% (287), 70% of all cases and 66% of operated cases (308) and 49% (286). Echlin et al (267) reported a group of fifty patients operated on in the first forty-eight hours with a surgical mortality of 90%. Cantore et al (306) also limited the definition to forty-eight hours for their forty-nine cases of supratentorial subdural haematoma and their

surgical mortality was 37%. In a paediatric series 19% died (328).

For subacute cases surgical mortality rates were 20% (281), 30% (267) (48 hours to 21 days), 41% (314), 14% (271), 27% (315 - uncomplicated cases only) and 1.4% (312).

As expected the surgical mortality rate among cases of chronic subdural haematoma is much lower: 6.1% (281) (6% of all cases), 25% (267), 23% (314), 8.7% (271), 2.0% died in hospital and a further 4.0% after discharge (309), 4% (288), 36% (310), 38% (289) and 0% (312). The high figures in the series of Levin and Gelfand (310) and Dronfield et al (289) are probably explained by the selection of patients and the associated misdiagnosis and delay in diagnosis. Fogelholm and Waltimo (318) and James and Turner (264) both highlighted that although operative mortality is low, many cases die undiagnosed. Thus 40% of the series described by Fogelholm and Waltimo (318) were first diagnosed at post-mortem. In a three year period in London there were eight hospital cases of chronic subdural haematoma and eleven coroners cases, only one of the latter having been operated on (264). Subdural haematomas in newborn infants were excluded from this series. In children with various types of subdural haematoma, mortality was 7.9% (325) and 22% (134).

The foregoing discussion of mortality in cases of subdural haematoma, clearly indicates that speed of onset influences mortality, since 48% - 90% of those operated on within twenty-four hours die, compared with 45% - 73% of those operated on upto seventy-two hours and 1.4% - 41% of those operated on from three to twenty-one days. Differences in mortality rates could in part be due to selection and/or differences in epidemiological aspects, such as age-distribution, proportions resulting from road traffic accidents and numbers with associated lesions etc. The high mortality in acute lesions has been considered to be due to the combination of associated lesions and the haematoma (267, 271, 281, 282, 305, 308, 313, 319, 326) although not all these authors place the emphasis in the same place. McLaurin and Tutor (283) found no

difference in mortality between their patients with and without intracerebral clots and believed the principal pathology was associated cerebral contusions rather than the subdural haematoma. Rosenorn and Gjerris (315) reported a series of pure subdural haematomas, excluding patients with associated macroscopic lesions, yet their mortality (73%) was as high as or higher than series including cases with associated lesions. Talalla and Morin (282) suggested two sub-groups, those with acute subdural haematoma alone and those with acute subdural haematoma and associated lesions. They maintained that the mass effect of any associated cerebral oedema may far exceed that of the subdural haematoma. In Hernesniemi's series (308) roughly half had additional intracerebral mass lesions. The mortality was higher and the useful recovery rate lower in this group than in the remaining half without associated mass lesions. Seelig et al (169) reported the significance of many variables in regard to their eighty-two comatose patients operated on within twenty-four hours. They concluded that associated intracerebral haematomas or contusions did not significantly alter the outcome. Although speed of onset affects outcome, this must be balanced by rapidity of surgical response. Seelig et al (169) found a significantly better outcome among patients operated on within four hours of injury. Outcome was also significantly better in women than men because women were operated on two hours sooner than men. The patients described by these authors were selected. Gutterman and Shenkin (337) reported delay in surgical intervention in patients with decerebrate rigidity resulted in increased mortality (27% of their 52 patients had acute subdural haematoma and decerebration). McLaurin and Iutor (283) found mortality was higher and recovery rate lower in patients operated on within twelve hours than in patients operated on from twelve to twenty-four hours after injury. Hernesniemi (308) also found a higher mortality in those operated on in the first six hours, when primary brain damage was severe and more important than the acute subdural haematoma. Both of these series were less selected than that of Seelig et al. Cooper et al (319) described fifty patients similar to those of Seelig et al and found that patients who survived were operated 1.65 hours earlier than those patients who died, although this difference

did not reach statistical significance. In a less similar series, Britt and Hamilton (305) found no relationship between outcome and the interval between arrival at hospital and operation. However, 60% of those operated on within three hours died compared with 50% of those operated on between four and six hours and 50% of those operated on between seven and twelve hours.

Outcome has also been related to conscious level. McKissock et al (281) reported that the level of consciousness on admission was related to mortality irrespective of the type of haematoma, so that a decreasing conscious level was associated with an increasing mortality. Furthermore, patients with an acute lesion were more likely to die than patients with a subacute lesion and the same conscious level. This correlation has been confirmed by other authors (267, 271, 282, 283, 287, 308, 315, 326). Richards and Hoff (313) discussing more acute lesions found no difference in the level of consciousness between survivors and non-survivors. Seelig et al (169) reported only on patients in coma. In subacute (281, 315) and chronic (267, 281, 310) cases the relationships between conscious level and mortality was found to hold true. However Cameron (288) reported no differences in survival between patients with differing conscious levels at the time of operation. Jamieson and Yelland (271) recognised five trends in the conscious level. For patients conscious throughout the mortality was 11% and for patients unconscious throughout was 65%, while for patients with a lucid interval it was 46%, for patients not initially knocked out, who subsequently became unconscious, it was 40% and for patients initially knocked out, who thereafter remained conscious, it was 6%. The type of subdural haematoma, in conjunction with the trend in consciousness, also affected mortality, such that patients with complicated lesions had a higher mortality than patients with simple haematomas and the same conscious level. As well as the trend in consciousness, the conscious level at the time of operation affected the outcome. Patients conscious at the time of surgery did better than patients unconscious at the time of surgery. The same relationship between complicated lesions and conscious level at operation was apparent as detailed above. In Jamieson's series,

patients with a lucid interval had a lower mortality whereas Richards and Hoff (313) found the opposite. McLaurin and Tutor (283) also found a complete or partial lucid interval indicated a better outcome.

Other neurological deficits also affect outcome predictably and adversely: decerebration (169, 271, 282, 319, 326, 337), bilateral pupillary abnormality (169, 271, 283, 287, 315), unilateral pupillary abnormality (271, 283, 315), impaired or absent oculo-cephalic or oculo-vestibular reflexes (169). Some authors either did not consider these aspects or found them unrelated to outcome. The report by Seelig et al (169) is particularly noteworthy. By studying only comatose patients the possible effects of varying conscious levels interacting with other neurological signs were to a certain extent obviated. Interactions between various deficits have been considered. Jamieson and Yelland (271) reported the mortality in patients with hemiplegia and abnormal pupils was double that in patients with hemiplegia alone; in patients with circulatory changes and eye signs, mortality was 41% and without eye signs 26%; in patients with decerebrate rigidity alone it was 89% and with fixed dilated pupils 95%. Gutierrez and Raimondi (328) found a higher mortality in their children with a worse level of consciousness, lateralising signs and fixed dilated pupils.

The relationship between mortality and outcome has been mentioned already in regard to speed of onset. In McKissock's series (281), twelve of fourteen patients with acute subdural haematoma and associated lesions died compared with thirty-two of sixty-eight patients with acute subdural haematoma alone. Jamieson and Yelland (271) reported an overall surgical mortality of 35%, for patients with an associated intracerebral haematoma it was 53% and when additional extradural and intracerebral haematomas were present it was 47%. In the presence of a single cerebral laceration mortality was 44% and in the presence of multiple lacerations 62%. Hernesniemi (308) found 67% of operated patients died and this rose to 78% when an intracerebral mass lesion was present. Furthermore a

useful recovery occurred in nine (13%) out of sixty-seven patients with intracerebral mass lesions compared with 26% (eighteen of sixty-nine patients) without an intracerebral mass lesion. McLaurin and Tutor (283) found no difference in mortality between their patients with and without intracerebral clots. In their selected series, Seelig et al (169) found that the presence of intracerebral haematomas or contusions did not significantly affect outcome. Jamieson and Yelland (271) related mortality to the type of haematoma present. Thus mortality was higher in patients with complicated lesions (53%) than in patients with simple haematomas (22%), fluid collections (20%) or contusions and haematomas (30%). Complicated haematomas were generally acute, associated with a worse conscious level and neurological deficits. The higher mortality reported by these authors in patients injured in traffic accidents was due in part to the higher incidence of complicated lesions in such patients. Frontal and temporal pole lesions were more often associated with complicated haematomas and a higher mortality. For simple haematomas the overall mortality was 22%, but 67% for simple haematomas occurring in the posterior fossa and 28% for bilateral simple haematomas. In McKissock's series (281) bilateral lesions would have a higher mortality since they were more often acute. Fell et al (307) reported the mortality in patients with bilateral lesions was double that of patients with unilateral lesions, while 8% of survivors and 37% of non-survivors had bilateral lesions in another series of very acute lesions (313). A higher mortality for bilateral lesions has also been reported by McLaurin and Tutor (283) and Talalla and Morin (282).

In patients with head injury, mortality is generally correlated with age as we have seen. In McKissock's series (281) mortality increased with increasing age for all types of haematomas. Jamieson and Yelland (271) however, found little difference in mortality until the age of seventy years. Complicated haematomas, which had a higher mortality, were much commoner in younger age-groups whereas simple haematomas, which had a low mortality, were commoner in older patients. This difference in the type of lesion may have been sufficient to balance or negate the

effect of age. This is borne out by the fact that mortality is lower in young women than in young men, young women having fewer complicated haematomas. McLaurin and Tutor (283) found age had no effect on survival among their cases of acute subdural haematomas, however, Talalla and Morin (282) had few survivors among their older patients. Fell et al (307) reported patients under forty years had a slightly better chance of surviving than did patients over forty years. Differences were particularly evident between patients under ten years of age (33% died) and patients over sixty years (69% died). Rosenorn and Gjerris (315) found mortality increased with age, 57% of patients under fifteen years dying compared with 85% of patients aged sixty-five years or more. VanderArk (287) however, found no significant age difference between those who died (median age 52 years) and those who survived (median age 51 years), although excellent outcomes were commoner in young patients (median age 40 years). In Hernesniemi's series (308), which included operated and non-operated cases, the highest mortality was in patients sixty years old or more (81%). Richards and Hoff (313) reported a series with more acute lesions, survivors had a mean age of thirty-six years and non-survivors a mean age of fifty-one years. Cooper et al (319) found no statistically significant difference in survival between patients under forty years and patients over forty years. Britt and Hamilton (305) found a steady increase in mortality with increasing age although the sample size in each decade was small. In patients upto forty years the mortality was 42% and in patients over forty years it was 75%. In their selected series Seelig et al (169) found patients with acute subdural haematomas were significantly older than patients with other types of severe head injury. No significant age difference was apparent between survivors and non-survivors of acute subdural haematoma or between male and female patients. Gutterman and Shenkin (337) discussed fourteen patients with acute subdural haematoma and decerebrate rigidity from among fifty-two patients with decerebration secondary to head injury. The average age of five survivors was forty-four years and of the non-survivors was fifty-one years. Decerebration or flaccidity was present in 47% of the patients described by Seelig et al (169).

McKissock et al (281) found no relationship between the volume of the clot and the prognosis, nor could McLaurin and Tutor (283) or Talalla and Morin (282). Haematomas ranged in volume from 50-400 mls in 85% of one series (313). The average size of the clot removed was 126 mls for survivors and 122 mls for non-survivors. However when the clot removed was greater than 100 mls only 20% survived compared with 36% when the clot was less than 100 mls. More than 80% of haematomas were larger than 100 mls in the series described by Britt and Hamilton (305). For those clots upto 100 mls the mortality was 71% and for those over 100 mls was 51%. In cases of chronic subdural haematoma Fogelholm et al (317) showed the thickness of the haematoma, as determined by angiography, increased significantly with age, which is in keeping with the age-related reduction in brain volume.

In addition to the above factors, Seelig et al (169) found significantly more women survived than men; significantly more patients who survived had a peak post-operative intracranial pressure of less than 20 mm Hg; uncontrollable post-operative intracranial pressure was significantly associated with a poor outcome; and differences in multi-modality evoked potentials were significantly related to survival and functional recovery. In regard to sex, women were generally in a slightly better neurological state but this difference from men was not significant. There was a significant difference between the sexes in that women were treated on average two hours earlier than men. Jamieson and Yelland (271), as mentioned earlier, found mortality lower in young women than in young men and explained this by the fact that complicated haematomas were less common in young women. Non-significant differences in patients with acute subdural haematoma were also reported by Seelig et al (169), thus although significantly fewer patients with acute subdural haematoma were injured in traffic accidents than by other means no significant differences existed between different sub-groups of patients with acute subdural haematoma. No significant differences existed between males and females except in regard to mortality, functional recovery and elapsed time to operation, females having a

significantly lower mortality and elapsed time and a higher recovery rate. When comparing patients with acute subdural haematoma to other patients with severe head injury not including subdural haematoma, patients with subdural haematoma were older, died more often, had a lower recovery rate and had a worse initial neurological state. These differences were all significant. No significant differences existed in regard to sex, severe morbidity, post-operative intracranial pressure or elapsed time to operation. Multivariant analysis of their data by these authors revealed sex, post-operative intracranial pressure, initial neurological examination and elapsed time to surgery were all significantly related to outcome in patients with acute subdural haematoma.

2.4.11 OTHER INTRADURAL HAEMATOMAS:

Jamieson (338) has analysed the surgical lesions occurring among eleven thousand patients admitted during an eleven year period. Such lesions occurred in 9.5% of patients and these one thousand and forty-five patients had twelve hundred and thirty-five lesions between them. This group included an undefined number of secondary referrals. Extradural haematomas occurred in one hundred and sixty-seven patients, associated with intradural lesions in 47%. Subdural haematomas occurred in five-hundred and fifty-three patients, 13% also had an extradural haematoma. Intracerebral haematomas occurred in sixty-three patients, a quarter also having extradural or subdural haematomas. Thus six hundred and ninety-three patients had single or combined post-traumatic intracranial haematomas. The ratio of subdural haematoma to extradural haematoma to intracerebral haematoma was 8.8:2.7:1. In a more selected series, El Gindi et al (323) found a ratio of 5.7:1.3:1. The above cases with extradural (225) and subdural haematomas have (271) already been discussed. In a further publication Jamieson and Yelland (339) described those cases with surgically treated intracerebral haematomas. Haematomas underlying depressed fractures or related to cerebral lacerations were excluded. Six patients had in addition an extradural haematoma and fourteen (including four with extradural haematomas) also had

subdural haematomas. In all cases with subdural haematoma the intracerebral haematoma was either contralateral or dealt with at a subsequent operation. The male/female ratio was 4.7 and nearly half of the males were aged 21-40 years. Incidence rose to a peak in 21-30 year olds, plateaued and then declined in those over sixty years. Traffic accidents accounted for 38% of cases and half of the deaths, with a preponderance in young males and in elderly patients, who were usually pedestrians. Sport, brawls and industrial accidents accounted for most of the remaining male cases and home accidents were common in the elderly. Haematomas were most often frontal (42%) or temporal (51%). Only one patient had an intracerebellar haematoma, which was accompanied by a frontal lobe haematoma. Six patients had multiple haematomas, bilateral in one case. In a further six patients the haematoma had ruptured into a cerebral ventricle. Temporal haematomas were most often due to lateral blows (60%) and were more often ipsilateral (58%). Frontal haematomas were more often due to occipital blows (46%). However nearly two-thirds of all haematomas resulted from a contre-coup mechanism. Blows were significantly more often on the right side of the head and haematomas were more common on the right but not significantly so. Nearly a quarter of cases presented within twenty-four hours, 62% by four days and only 9.5% longer than two weeks. A lucid interval occurred in 19%, which was more often than in extradural (12%-225) or subdural (13%-271) haematomas. 49% were not initially knocked out and of these two-thirds remained conscious throughout; 14% were unconscious throughout and 17% remained conscious after being knocked out initially. The trend in conscious level was significantly related to mortality but not to the site of the lesion. Headache was a common symptom occurring in 24%, two-thirds of whom were also irritable or restless. Nearly a third had an abnormality of one pupil and 7.9% abnormalities of both pupils. Hemiplegia occurred in half of all patients. Other findings included aphasia (21%), epilepsy (16%), bradycardia (14%), hemianopia (7.9%), decerebration (4.8%), hypertension (3.2%), respiratory depression (3.2%) and hyperthermia (3.2%). Only 46% of patients had skull X-rays and of these 59% had a skull fracture. Overall surgical mortality was 25% and was significantly related to

conscious level, both to the trend and the conscious level at operation. Mortality was higher in patients with bilateral pupillary abnormality, decerebration, rapid onset and cerebral lacerations. Mortality did not vary with the site of the haematoma.

Cruikshank et al (300) described a case of paraventricular haematoma in an amateur boxer, and Jamieson (340) two cases of delayed traumatic intracerebral haemorrhage. Sokol and Rowed (341) described one case of traumatic right intracerebellar haematoma with a short, partial lucid interval. Bilateral bloody cerebro-spinal fluid otorrhea was present and two linear right occipital fractures were evident on the skull X-ray. The haematoma was associated with a laceration of the right cerebellar cortex.

Intraventricular haemorrhage was found in 3% of two hundred consecutive patients with blunt head injury undergoing investigation by computed tomography (342). Half of these patients also had contusions or intracerebral haemorrhage. All six patients were male with an age range from 12-31 years, two patients died. Each patient was the victim of a traffic accident and none had a normal conscious level on admission; one was decerebrate and two more had a hemiparesis. In each patient blood was present in the lateral ventricle alone or in addition to other sites. In an earlier study 56% of two hundred CT scans in head-injured patients were abnormal (251). Of the abnormal scans 37% showed subdural haematomas (bilateral in a third), 18% showed intracerebral haematomas, 4.5% extradural haematomas and 3.6% intraventricular haemorrhage. Contusion/oedema/mass effect was the commonest abnormality, occurring in 40%. Merino-de-Villasante and Taveras (343) found a similar proportion of patients had intraventricular haemorrhage in a retrospective study of one hundred cases of head injury undergoing CT examination. In two of their three cases an intracerebral haematoma was closely related to the intraventricular haemorrhage. In a larger series of three hundred and twenty patients with blunt head injury who underwent CT examination, 6.3% had intracerebral haematomas and in a third there was intraventricular extension (344). A further large series discussed five hundred patients with

head injury, fifty were excluded because the CT scans were of poor quality (345). Intraventricular or cisternal haemorrhage occurred in eleven patients, multiple haemorrhages and accompanying lesions were not uncommon. Zuccarello et al (346) discussed ten cases of intraventricular haemorrhage, accounting for 2.9% of cases of blunt head injury undergoing CT examination. Eight patients had accompanying contusions, extra or intracerebral haemorrhage and the remaining two had no other abnormality. Eight patients were injured in road traffic accidents, the age range was 17-81 years (average 42.6 years) and only one patient was female.

Cordobes et al (347) identified thirty cases of post-traumatic intraventricular haemorrhage occurring during a three year period. These accounted for 2.1% of all patients with head injury undergoing CT scan and 7.1% of all severe head injuries during the same period. The male/female ratio was 1.7 and the average age 34.6 years with a range from 2-78 years. Severe head injuries were those in coma for at least six hours, who were unable to utter words, obey commands or open their eyes in response to painful stimuli. Three further patients with intraventricular haemorrhage were excluded because the diagnosis was not made until after operation, as were two patients with a doubtful history of trauma and one patient with a ruptured aorta. Most of those included were injured in road traffic accidents. Most often bleeding occurred into the lateral ventricles either alone or as well as at other sites, only 6.7% did not have bleeding into the lateral ventricles. Isolated intraventricular haemorrhage occurred in only two patients (6.7%); associated diffuse brain injury was present in 53%, global contusion in 20%, focal contusion in 6.7% and subdural haematoma in 13%. In 37% of cases direct spread of blood from intracerebral haemorrhage had occurred, while 40% showed evidence of brain-stem injury and 80% bleeding in the posterior interhemispheric region. Predictably the majority of patients described had abnormal motor responses (83%) and pupillary abnormalities (93%). One fifth of the patients were operated on, usually to evacuate a subdural haematoma. The overall mortality was 77%. The average age of survivors was 19.8 years and of

non-survivors was 40.7 years and 61% of deaths occurred during the first twenty-four hours. Mortality was related to neurological status as determined by the best score on the Glasgow Coma Scale during the first twenty-four hours. Clot volume did not correlate with final outcome.

2.5 SKULL RADIOLOGY:

Following articles by Bell and Loop (348), Harwood-Nash et al (217) and Roberts and Shopfner (349), the last decade has seen a vigorous debate concerning the place of skull X-ray (SXR) in patients with head injury (58, 93, 350-364) and generated considerable correspondence (365-385) and editorial comment (386-389). Latterly this question has been put into some perspective by De Lacey et al (355) and Jennett (93) and in studies carried out under the auspices of the Royal College of Radiologists (361-363). These works have revealed a dichotomy of opinion. On the one hand radiologists hold that skull X-rays are over-used in regard to head-injured patients, rarely affect management decisions, rarely show positive findings and are generally wasteful of resources (348, 349, 357, 359, 360, 361, 386). The opposing view, usually voiced by neurosurgeons (93, 365, 368, 370, 376, 378, 379) and accident surgeons (384, 385), holds that skull X-ray is indispensable in head-injured patients in that it identifies patients at risk from complications such as intracranial haematoma (78, 250) or infection (390-392), or may identify patients requiring admission who would otherwise be discharged (93).

In the majority of British hospitals a skull fracture can be identified in one of four ways, clinically, radiographically, at operation or at post-mortem. The latter two instances are fortunately less common methods and by their nature indicate that important decisions have already been made or are too late. For practical purposes therefore, the presence of a skull fracture must in the majority of patients be either clinically or radiographically determined. The clinical diagnosis of a fractured shaft of femur or Colles' fracture is relatively easy. Similarly the clinical suspicion of a fracture of the wrist or ankle is often confirmed radiographically. The diagnosis of a fracture of the distal phalanx of a finger, of the nasal bones or of a toe does not determine management and many would agree that X-ray in such circumstances was redundant. Similarly the radiological search for an isolated rib fracture is considerably less important than the search for a

pneumothorax in the same patient, so that a chest X-ray rather than oblique rib films is all that is required. When a head-injured patient has bilateral bruising of the upper eyelids, CSF otorrhoea or brain leaking from a scalp wound the clinical diagnosis of skull fracture is certain even though subsequent radiological evidence may be lacking. Experienced doctors are often surprised, particularly in children, to find a skull fracture radiographically when they had little clinical reason for suspecting such a fracture (or even for X-raying the patient). It is probably true to say that certain clinical diagnosis of skull fracture is the exception and that skull fracture may occur without external evidence of injury to the (unshaved) head. These facts in part explain why skull X-ray is so often requested in head-injured patients, yet is so often negative. Radiologists more than most are necessarily likely to be aware of this fact. The purpose of this section is to review recent articles addressing the efficacy of skull X-ray in head-injured patients.

From the epidemiological review presented earlier, the number of skull X-rays per annum in the UK for head injury can be estimated at about 600,000 since not all head-injured patients have a skull X-ray. According to Swann (50) 65% of adult A&E patients with head injury had a skull X-ray. A third of those with radiologically apparent skull fractures had neither altered consciousness, post-traumatic amnesia, epilepsy, focal signs, headache nor vomiting (50, 384). Furthermore 46% of those with a fracture had no scalp wound. Strang (18) reported 58% of over three thousand A&E patients of all ages with head injury had a skull X-ray and 2.7% of these had fractures. The proportion of A&E patients with head injury who had skull X-rays was even less in Nottingham where 30% had skull X-ray and one in forty of these had a skull fracture (385). As one would expect, nearly all admitted head injuries (93-97% according to MacMillan et al) have skull X-ray and 7% have skull fractures (25). In Burkinshaw's series (60) of head-injured children, 85% had skull X-ray and 23% of these had a fractured skull. In three Scottish neurosurgical units 60% of patients had a skull fracture (29).

Fracture of the skull is commoner in those with more severe head injury (18, 25, 158) and in children (25, 60, 61, 62). In Canada 90% of 4,465 children with head injury had skull X-rays within twenty-four hours of admission (217). 27% (1187 cases) of the total number had a fractured skull on X-ray while a further 5.8% (257 cases) had a CSF leak (36 cases) or blood in the middle ear (221 cases) but no fracture demonstrated on skull X-ray. Only three of those with a CSF leak and twenty of the two hundred and forty-one with blood in the middle ear had X-ray evidence of fracture. Of the 1187 with skull fracture only 72% had external evidence of head injury and in a little over three quarters of these such evidence was ipsilateral to the fracture, in 15.5% such evidence was contralateral and in the remaining 8.5% the relationship between the two was not stated. At least 39% of children with fracture therefore, had either no external evidence of injury (28%) or evidence only on the opposite side (11%), indicating the difficulty clinically of accurately diagnosing skull fracture in children.

Between 11% and 25% (211, 224, 226, 228, 229,) of all patients developing extradural haematoma do not have a skull fracture on X-ray. Galbraith (250) abstracted patients with extradural haematoma and no skull fracture on X-ray from two published series and added ten patients from the Institute of Neurological Sciences and concluded that 91% of patients with extradural haemorrhage but without radiological evidence of skull fracture were under thirty years of age. Furthermore, he stated that an adult hospital admitting 1000 head injuries per year can expect an extradural haematoma to occur in a patient over thirty years without a skull fracture only once every thirty years, moreover, such a patient is likely to have neurological signs.

Jennett (93) maintains that in the mildly injured patient, who is the patient most likely to be sent home, the presence of a skull fracture increases by about four hundredfold the likelihood of an intracranial haematoma developing. Failure to make this diagnosis early enough by failing to diagnose a skull fracture can only lead to unnecessary morbidity and mortality because of delay

(21, 78, 190, 191, 233) Galbraith (78) has shown that misdiagnosis and delay are particularly likely to occur in patients wrongly labelled as drunk or the victims of a stroke. He showed that in such patients the presence of a fracture when recognised did not lead to appropriate diagnosis and treatment. Jennett (93) has stated that finding a fracture in such a patient increased by about twenty times the likelihood of an intracranial haematoma developing.

In a deteriorating patient a fracture shown on skull X-ray may be the only indication of the likely site of a haematoma, although operation should not be delayed for this investigation to be performed. Pertinent to this point is the case described by McCulloch (232). This concerned a young man injured in a road traffic accident, who was not knocked out at the time, but who, four hours after the accident, was found unconscious at home and two hours later, when first seen by a doctor, was decerebrate. A further three hours elapsed before transfer to a neurosurgical unit, when the patient was decerebrate on both sides and deeply unconscious with small equal, sluggishly reacting pupils. There was no external evidence of trauma, skull X-ray could not be performed and immediate bifrontal and bitemporal Burr holes revealed tense and swollen brain but no haematoma. Intraoperative carotid angiography showed severe hydrocephalus but no midline shift, however an occipital fracture was visible on the angiograms. Urgent posterior fossa exploration revealed below the hair a moderate sized occipital bruise overlying a depressed fracture and an extradural haematoma. Two months later the patient was neurologically normal and had returned to full time work. Cases 3 and 4 described by Hooper (235) also illustrate the value of a fracture found on skull X-ray in directing the surgeon to the appropriate site. In the same article Hooper also states that early radiography is of the utmost importance in all head injuries.

Jennett (393) discussed cases of head injury reported to the Medical Defence Union and Medical Protection Society over a five year period. In 63% of the hospital cases X-ray mishaps occurred, in sixteen of these thirty cases no X-ray was taken, nine were

X-rayed but the fracture was missed and five had a delayed X-ray report. Significantly, fourteen out of the thirty were X-rayed and the X-ray did not confer benefit. All patients originally discharged from hospital and who later developed complications had irregularities regarding their skull X-ray. Acute intracranial haematoma was the commonest cause of death in those dying.

Robinson (394) reported that in New Zealand the incidence of all depressed fractures was similar to that for a lightly industrialised American area, which he quoted as 3.4/100,000 per annum. No more than a quarter had had a severe injury and adequate X-rays were essential, because without them diagnosis was readily missed with the risk of intracranial infection. Basal fractures require antibiotic prophylaxis and occasionally neurosurgical intervention. Miller and Jennett (390, 391) have also discussed depressed fractures and particularly how such patients often came to harm because skull X-ray was omitted. Thus infection occurred as a complication in thirty-eight patients (9.5%) in their series, in nine of these the depressed fracture was missed in the A&E department (390). None of the nine had been knocked out, seven had not been X-rayed and in the two X-rayed the fracture had been missed. Intracranial haematoma occurred in twenty-eight patients, 7% of the series, five of these, who had not been knocked out, were discharged from the A&E department. These authors stated that for the diagnosis of most depressed fractures skull films are essential. Sande, Galbraith and McLatchie (392) reported a more recent retrospective series of 216 patients with compound depressed skull fractures from the same centre as Miller and Jennett. In this series the incidence of infection following depressed fracture had fallen significantly compared to the earlier series from 10% to 4%. This decrease was attributed by the authors to improved training of junior surgeons leading to more appropriate and earlier treatment. Of the nine patients who developed infection, five had established infection prior to referral to the regional neurosurgical unit, although two of these five presented forty-eight hours after injury, in two more the fracture was missed (one not X-rayed) and in the final patient for geographical reasons X-rays were not taken and

only simple cleaning and dressing was undertaken. In two of the four patients developing infection after referral, faulty surgical technique was held to be responsible. Altogether five of the nine cases of infection were considered by the authors to be preventable, none of the affected patients died but one was left moderately disabled. Although there had been marked improvement in preventing infection, delay in referral and inadequate treatment remained the commonest reasons for infection developing.

In 1926, Dandy (395) described three cases of intracranial air identified on skull X-ray and was able to find only twenty-five cases in the world literature up to that time. Briggs (396) reported that the incidence of traumatic pneumocephalus among 15,425 head injuries admitted in ten years was 0.2%, while the incidence of extradural haematoma in the same group of patients was 0.5%. The true incidence was probably less than this since the Oxford unit included secondary referrals. The finding of intracranial air is important because it indicates the possibility of infection developing and because the air may act as a mass lesion. Briggs recognised two types of intracranial air - intracerebral and extracerebral. The latter type was nearly twice as common as the former and was nearly always apparent on the initial skull X-ray although often missed by the admitting doctor (8 of 19 cases). Usually it was associated with a frontal injury and about half had a facial fracture and about three quarters had CSF rhinorrhoea. Most settled within fourteen days and less than half required surgery to repair a dural defect. The former group had also most often received a facial or frontal injury, although air was not always apparent on skull X-ray until late, often coinciding with the onset of CSF rhinorrhoea, which occurred between four and thirty-five days after injury. All required surgical treatment to relieve elevated intracranial pressure and to repair the dural fistula. One tenth of those with extracerebral air had not been concussed, while a sixth of those with intracerebral air were not concussed and a further quarter had a PTA of only a few minutes. Six out of eleven cases of extracerebral air with no adequate prophylaxis developed meningitis, none of those with adequate prophylaxis developed meningitis.

In a quarter of adult A&E attenders with head injury who had skull X-ray, the radiologist considered one or more views inadequate, although nearly all were considered satisfactory by the A&E staff (50). Alcohol was not considered responsible for the inadequacy of the films. In the same article it was reported that three out of twenty-four fractures were missed by the A&E staff while in two additional patients the A&E staff diagnosed a skull fracture which was not subsequently confirmed by the radiologist. These findings are similar to those of an unpublished study by Jennett, Johnston, and Macphie (quoted by Jennett-93), who found wrong exposure to be the commonest cause of unsatisfactory films, only 6% of blurred films being due to patient movement and even in unco-operative patients nearly a half had satisfactory films.

Jennett (93) proposed a further use for skull X-ray in head-injured patients, at least in Britain. This relates to CT scan which ideally should be undertaken before signs develop but where there is good reason to suspect that a post-traumatic intracranial haematoma may develop. One such good reason is the presence of a fracture on skull X-ray. Thus skull X-ray may assume additional importance as a method of selecting patients for investigation by CT scan in countries where this is a scarce resource, since in the majority some form of 'bussing' to the regional neurosurgical unit would be necessary.

It is clear from the foregoing discussion that in over 90% of A&E patients and patients admitted to general surgical wards no skull fracture will be present on skull X-ray. However, this finding in a patient with a compatible clinical picture will suggest the diagnosis of severe diffuse white matter shearing injury (93) or may cause alternative (non-traumatic) possibilities for an altered conscious level to be more correctly pursued. Apart from fractures and intracranial air other positive findings may be evident on skull X-ray - fluid levels, pineal shift or foreign bodies as well as serendipity findings such as calcification in tumours or aneurysms, cysticercosis, etc.

Before discussing individual papers consideration will be given to a paper by Cummins (353) which is of general interest, offering as it does further explanations of why doctors order skull X-rays. This article was complimentary to one to be discussed later dealing with a prospective study of the use of high yield criteria and concentrated on those skull X-rays requested in patients who did not fulfil the high yield criteria in operation during the study period. This group comprised 80% of those having skull X-ray during the study period. Conclusions were based on answers to a questionnaire and on the results of interviews of the hospital junior medical staff. Interpretation of the results was subjective but nevertheless interesting. Reasons for ordering skull X-rays when not justified by the high yield list (HYL) included: disagreement with the HYL because important indications for skull X-ray were omitted, the belief that X-ray was a central component of the overall evaluation of the patient and allowed decisions to be made more easily and confidently, patient and relative request with which it was easier to comply than to argue, peer or mentor pressure, fear of malpractice suits, efficient management of time or temporal spacing of neurological examinations, fear of mislabelling a patient as well and occasionally for no other obvious reason than routine. The author concluded that requests for skull X-ray were highly discretionary and not attributable to ignorance of the disease under consideration or the procedures used for evaluation. He further concluded that non-compliance was not for perverse reasons but rather for honestly held indications which were neither irrational nor reprehensible.

In North America as we have seen, skull fractures occur in about 30% of acute head injuries (134, 152, 154). It has already been suggested that this higher incidence compared to British studies is more likely due to selection operating via a different admission policy than to a true difference in incidence. The same explanation is also probably true at least in part for the high incidence of skull fracture in other series around the world e.g., Australia - 40% (121), Canada - 27% (48, 134), Formosa - 25% (137), India - 29% (140). Accordingly, British studies will be grouped

together and discussed first before proceeding to consider studies from other countries.

Concern has recently been shown by British radiologists in regard to the increasing number of requests for radiography (355, 386, 397, 398). One of the areas in which they have suggested that radiography is over-used is in relation to head injuries (355, 357, 361-3, 386, 397). Part of their argument is that because skull X-ray rarely reveals a fracture it must be a futile procedure, but as we have seen, clinical diagnosis of skull fracture is not often possible and there are cogent reasons why the presence (or more commonly absence) of a skull fracture should be determined. Mere scarcity of positive findings cannot be a reason for not undertaking an investigation, especially when other practical means for identifying such an abnormality do not exist. It is against this background and in the light of the previous observations relating to the relevance of finding a skull fracture that the following studies must be judged.

Burkinshaw's paper (60) relating to head injuries in children has been discussed in the epidemiological section. The author concluded that skull X-ray is not indicated except: to verify that a head injury has occurred when the suspicion of such an injury exists but there are no external signs, to confirm a clinically suspected depressed fracture or to define the extent of bony damage in cases where immediate surgical treatment is contemplated. The first reason will necessitate many X-rays being undertaken since in children no adequate history may be available and often fractures exist without external evidence. The second reason cannot be upheld since many depressed fractures are not suspected clinically (390, 391). The third reason is more defensible. Burkinshaw's argument against routine skull X-ray in head-injured children is based on a consideration of the seventeen cases (7.1%) who developed complications. Nine of these had a skull fracture on X-ray so the incidence of complications was the same whether a fracture was present or not. However, if new complaints of headache (8), vomiting (1) and depression (1), which few would see as a

complication, are excluded from the list, only nine would have complications and seven of these would have fractures. Therefore fracture predicts complications more accurately than the severity of head injury as defined. Four of his patients had depressed fractures, one of the four was missed clinically and another was diagnosed clinically but not confirmed radiologically. He does not discuss compound depressed fractures, intracranial haematoma etc. He poses three questions in regard to skull X-ray in children:

1. Does the finding of a skull fracture make necessary any change in the treatment of the patient?
2. Does such a finding afford more reliable guidance than clinical assessment alone as to the probability of complications?
3. Does such a finding afford more reliable guidance than clinical assessment alone as to the probability of sequelae?

The author concluded from his results that the answer to each question was no. However a more critical appraisal of his results and a more realistic definition of complications, together with the facts outlined at the beginning of this section would suggest that the answer to each question is yes.

Boulis et al (58) reported a series of children under twelve years of age with head injury, although their patients were all out-patients initially. Neither head injury nor admission policy were defined. Included in the study were 1000 of 1032 consecutive out-patients with head injury who had skull X-rays performed. Thus 97% of head-injured children had skull X-ray - a very high figure. The sex ratio of 1.8 is a little below that in other British series (60-63) and the classification of causes into accidental (93%, mainly falls), road traffic accidents (6%) and NAI (1%) is rather limited. 2.1% of those X-rayed had fractures, which included fractures of the facial bones (0.3%) except the nose, as well as vault fractures (1.8%). 13% were admitted, again rather a

low proportion. More than half of those patients with skull fracture had no soft tissue injury to the head, underlining the difficulty of the clinical diagnosis of skull fracture. All twenty-one patients with fractures were admitted, although how many were admitted because of the fracture alone is not stated. Within forty-eight hours 93% were discharged and of those staying longer, two thirds had social problems (NAI) and a third had multiple injuries. The authors concluded with a list of indications for skull X-ray which would decrease X-ray by 36%, but they do not say how many fractures would be missed if these indications were applied. Furthermore, one of their indications is medico-legal reasons, despite their saying only medical reasons exist. They also stated there is no correlation between symptoms, physical findings and the likelihood of skull fracture. One must ask therefore how a fracture can be diagnosed except by X-raying all patients.

In 1978 Eyes and Evans (357) reported a series of five hundred and four patients with head injury attending A&E departments at two Liverpool hospitals. All these patients had skull X-ray. No definition of head injury was given, nor the age-distribution of the patients, nor over what period the patients presented and whether they were consecutive, nor causes, nor what proportion of patients with head injury were not submitted to skull X-ray during the same period of time and finally no indication was given of the admission policy at the two hospitals. The study was retrospective. Patients were categorised as symptom-free or not, symptoms included headache, mild concussion, a history of being knocked out and vomiting. Patients were also classed as CNS positive if they exhibited focal or general CNS signs. Nine patients (1.8% not 1.9% as quoted) had skull fractures on X-ray, rather lower than other series (18, 50) and 55.6% (not 57.5%) had pineal calcification, but there were no cases of pineal shift. One of the nine fractures was missed in A&E and this patient was lost to follow-up, so whether he came to harm because of the missed fracture is unknown. About a quarter were admitted and of these 6.2% had a fracture on skull X-ray. Nearly three-quarters were admitted for less than twenty-four hours and of the remainder only a seventh were detained because of their head

injury, medical problems or other injuries accounting for most staying longer than twenty-four hours. One of the admitted patients developed a subdural haematoma and had a normal skull X-ray. A further patient with a normal skull X-ray deteriorated rapidly after admission and an emergency carotid angiogram revealed an unsuspected left parietal tumour.

At least a quarter of the eight admitted patients with skull fracture had their management altered because of the finding of a fracture - One required elevation of a depressed fracture and one required prophylactic antibiotics. A further patient with a basal fracture died from multiple injuries soon after admission. Whether or not the remaining five patients had their management altered by the finding of a fracture on skull X-ray is unclear since the reason for admission in these patients was not given, nevertheless observation was the only treatment required for these patients. Of the nine patients with fractures, four had not been knocked out, three were CNS negative, six had scalp haematomas and three had scalp lacerations, but it is not stated if these overlaid the fractures, three were asymptomatic yet five had headaches and/or concussion. Some of Eyes and Evans conclusions were that:

- a) The detection of a skull fracture does not determine the need for hospital admission,
- b) Skull X-rays are a routine investigation rather than the consequence of a clinical decision,
- c) Skull X-ray findings seldom alter management,
- d) No medico-legal reason for X-ray should exist unless there is a medical one,
- (e) Nearly all patients with head injury attending A&E departments in Britain have a skull X-ray,
- (f) The yield of positive findings is low,

(g) Selection for admission by excluding a fracture radiographically would not save money, since X-ray findings bear little relation to brain damage.

The first of these conclusions is clearly false in the light of the preceding arguments; similarly the second and fifth which are related are also incorrect since only about 60% have a skull X-ray (18) and as Cummins (353) has shown, reasons are logical and coherent. Conclusion number three is refuted by the authors own study since at least a quarter of the patients with fracture had their management altered. The fourth conclusion is sound but in any case contributes to only a small proportion of skull X-rays. Similarly, few could deny the truth of the sixth conclusion but scarcity is not equivalent to unimportance, nor does it mean that skull X-ray has a limited value in the management of head injury. Finally, their last conclusion is also erroneous. Most admitted patients are neurologically normal and are admitted because they are considered to have an increased risk of developing complications. Such complications can be predicted from the presence of a skull fracture which would mean more could be discharged and money therefore saved.

Further useful discussion of this paper can be gleaned from the correspondence it generated. In reply to Dr. Sarkies letter (399) Eyes and Evans (374) indicated that three patients with skull fracture but no other reason for admission were admitted i.e., their management was altered. Therefore five out of seven (excluding the patient dying) had their management altered.

De Lacey et al (355) undertook a retrospective study of one hundred and thirty consecutive patients attending the A&E department of a London teaching hospital and who were referred for skull X-ray. All ages were included and although head injury was not defined, nearly all were mildly injured. The causes of injury were typical of an urban A&E department with a higher incidence of assaults and lower proportion of road traffic accidents. Nearly a third of those referred for skull X-ray had only a history of facial

trauma. Four patients (3%) had skull fractures, so that conclusions based on these patients cannot be generalised because of the small size of the sample. Half of the fractures were missed by the A&E staff and both had lacerations, although whether the skull fractures were compound was not stated. Both the remaining patients had a history of being knocked out, both were admitted and one had prophylactic antibiotics. Overall 17% were admitted, 88% of them for less than forty-eight hours. 97% of skull X-rays were technically adequate. 76% of patients had an X-ray of the cervical spine, facial or nasal bones as well.

In discussing their results and those of others De Lacey et al (355) agreed that the presence of a skull fracture on X-ray is important to know and may be more important in adults than children in regard to linear fractures, whilst this knowledge in children may be the only way of finding a compound depressed fracture. With some provisos they also agreed that the presence of a skull fracture may be one of the factors used to select for admission those patients with head injury most at risk of developing complications.

Most recently the Royal College of Radiologists have reported the results of a national study of skull X-ray in head-injured patients (361, 362, 363). The first of these articles (362) set the scene by prospectively sampling nine British A&E departments, selected as representative of the whole country, over a period of ten weeks. All consecutive patients having skull X-ray were included irrespective of age and for 95% of these patients the information required was complete. A preliminary pilot study was undertaken in each centre. Each clinician requesting a skull X-ray was required to answer a series of ten questions relating to his examination of the patient and then give his opinion as to the likelihood of a skull fracture being present based on his clinical assessment alone. Finally he was requested to state what management he would advise in the absence of skull radiography. Disposal details and X-ray findings were filled in subsequently. Head injury and admission policy were not defined, although radiological findings and clinical management were standardised according to

previously agreed but unstated criteria.

5850 patients were included in the study, representing about 0.5% of all patients with head injury attending British A&E departments each year. The age-distribution closely resembled that already determined in the epidemiological section of this thesis, although including slightly fewer children and more elderly patients. The sex ratio was also what one would expect from the epidemiological section. The number of patients with head injury not X-rayed in the same departments during the same period was not given. Of those X-rayed 2.1% had fractures, rather lower than the proportion found in Scotland - (3% - 17, 2.7% - 18). Also, surprisingly, they found the incidence showed little variation with age despite 44% of all fractures and three quarters of depressed fractures occurring in children, who represented 37% of the total X-rayed, the proportions for adults (16-64 years) were 43% of fractures, 51% of patients and for the elderly 13% and 12% respectively. 83% of all patients had no other injuries or diseases. 11% had other injuries and the remainder a variety of medical conditions.

Not surprisingly most X-rays were requested by SHO's (90%) and least by consultants (4%). In a little over a quarter of cases the clinician ordering the skull X-ray was certain clinically that no skull fracture was present, which the authors took to mean that these requests were made for defensive purposes. What proportion of fractures occurred in this group of patients is not stated, however, 27% of fractures were not clinically suspected prior to X-ray and from Table IV it can be concluded that one in eight of all fractures occurred when the clinician was certain that no fracture was present. Their conclusion that the clinical diagnosis of fracture definitely absent (99% correct) was accurate is not surprising. However, what is more important is diagnosing clinically that a fracture is present, something which is usually much more difficult. Since only 2% of these patients had a fracture, diagnosing all patients as having no fracture would still be 'surprisingly accurate' (98%) but would leave one hundred and

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twenty-two patients at serious risk. They further concluded that skull X-ray would directly contribute to the avoidance of death or secondary brain damage not more than once in every 1460 patients radiographed.

The incidence of post-traumatic intracranial haematoma was 12/10,000 A&E attenders having skull X-ray or roughly equivalent to 7/10,000 of all A&E attenders with head injury if about 60% had a skull X-ray. Similarly traumatic aerocele had an incidence of 1.7/10,000 A&E attenders having skull X-ray and 1/10,000 of all A&E attenders with head injury. Skull fracture had an incidence of 210/10,000 X-rayed (126/10,000 all) and depressed fracture 7/10,000 (4/10,000 all patients) (CF. 394).

The results from this study were further amplified and discussed in another paper (361). Patients were categorised according to the presence or absence of clinical symptoms and/or signs revealed by the answers to a questionnaire completed prior to skull X-ray. Three groups of patients were identified:

- a) 1021 patients (17%) had complicated head injury, i.e., an additional injury or disease. Fifty-five (5%) of this group had a skull fracture, representing 45% of all fractures. Four patients, all with fractures, developed intracranial haematomas and three died within forty-eight hours. One patient had an aerocele which was not discovered until two weeks after discharge from hospital.
- b) 3328 patients (57%) had no associated injuries or conditions and no symptoms or signs referable to their head injury. Twenty-three patients (0.7%) had a skull fracture (19% of fractures) and one patient, with a skull fracture, developed an intracranial haematoma.
- c) 1501 patients (26%) had no associated injuries or conditions but did have symptoms and signs. Forty-four (3%) had skull fractures (36% of all fractures) and three

developed intracranial haematomas. One of the latter three did not have a fracture. All would have been admitted on clinical grounds.

Of eight patients developing an intracranial haematoma, seven had a skull fracture, the remaining one patient with only symptoms and signs would have been admitted on clinical grounds, although the grounds were not stated. Only the patient in group b was identified by skull X-ray alone. This emphasises the point made by Jennett (93) that in the mildly injured patient, who is the patient most likely to be discharged, the presence of a skull fracture markedly increases the risk of an intracranial haematoma developing. The increased risk based on this one patient being infinitely greater compared with Jennett's estimate of 400 times. In patients in group a, the risk is also increased infinitely by the presence of a fracture and in group c by 69 times, whereas for all 5850 patients taken together the relative risk is 349. The authors estimated the radiological cost of identifying the patient in group b who developed a haematoma as £43,200. This may be set against the possible legal costs of not X-raying patients which are likely to be several times the radiological cost.

The authors devised a 'simulation' whereby the patients in groups b and c would be admitted or not without recourse to skull X-ray and showed by this means that admissions increased by 70% while 36% of patients with fracture and one patient out of four with intracranial haematomas would be discharged. Cost benefit analysis of this admission policy compared with current practice was undertaken. Admission without X-ray cost about £11,000 less provided one accepts that patients admitted without X-ray would stay less (1.3 days) than patients admitted using the current practice (1.4 days). The authors do not provide sufficient information for this decreased stay to be verified by the reader. In addition this saving would have to be set against legal costs. The authors go on to argue that the risk of developing unsuspected intracranial haematoma with skull fracture in patients with uncomplicated head injury currently X-rayed, is about 1 in 4800 i.e., one patient from

groups b and c ($3328+1501 = 4829$). In fact this underestimates the risk which is derived from one patient only, the patient in group b thus the risk is 1 in 3328.

In a third publication the costs and benefits of six different patient selection guidelines were compared (363). These guidelines were applied to only those 4829 patients with uncomplicated head injury i.e., groups b and c above. Patients with uncomplicated injury who were not X-rayed were again excluded. None of the selection guidelines led to the detection of more than 94% of skull fractures (range 58-94%). Half of the selection guidelines correctly identified all seven patients with serious outcomes, whereas the remaining selection policies each identified only 86% (6 patients) of serious outcomes. The maximum calculated saving in radiological costs of the six policies compared to current practice was 73% (range 21-73%). By omitting patients with uncomplicated injury who were not X-rayed but who would nevertheless have fulfilled the criteria of some of the six selection guidelines for skull X-ray, the authors overstated the benefit of such policies.

Many of the errors made by radiologists in evaluating the importance of skull X-ray in the management of head-injured patients are evident in an editorial by Evans (386). He said that radiologists have known for a long time that radiography of the skull in cases of trauma is of little value. He offers no supportive evidence for this view and clearly it is erroneous when the value of skull X-ray as described earlier is appreciated. He went on to state that irrespective of the severity of the injury skull X-rays are considered mandatory in such patients if they attend hospital. However, as we have seen, about 40% of head-injured patients who attend A&E departments do not have skull X-rays (18, 50). A further statement suggests that the presence or absence of a fracture seldom affects management, which is again not the case. Finally he suggests medico-legal considerations lead to nearly a half of skull X-ray requests while de Lacey (398) suggest that only 5% of all X-ray requests (many of which are for skull X-ray) originating from A&E departments are for purely medico-legal

reasons. Boulis et al (58) and Cummins (353) also found this reason to account for only a small proportion of requests for skull X-ray.

In 1971 Bell and Loop (348) published an article discussing the utility and futility of skull X-ray. This article has stimulated many other authors to research this topic. The article reported a prospective study of fifteen hundred American patients having skull X-rays during a fourteen month period upto May, 1970. All age-groups were represented, although it is not stated if the patients in the study group were consecutive. Neither head injury nor admission policy were defined. In 10% of the patients having skull X-ray the study questionnaire was incomplete and of these, those found to have a skull fracture had a questionnaire filled in retrospectively, but their number was not stated. Patients among the 10% who did not have a skull fracture apparently did not have a questionnaire filled in retrospectively and again their number was not stated. Many of those not having a questionnaire filled in initially might have been critically ill. Any findings considered equivocal or unobtainable were counted as negative (again numbers not stated). The authors admitted that completing the questionnaire probably dissuaded House Officers from ordering skull X-rays. Two cases of significant pineal shift without skull fracture were classed as fractures, while twenty-six old fractures were excluded. Most of the faults in the design and method of this study would act to increase the proportion of patients with positive findings.

Three 'unusual' cases were reported. In the first, the chance of fracture was considered to be 1 in 100, although the patient described is of a type easily underestimated. The authors suggested that in the second case medico-legal considerations were the primary reason for X-ray where the chance of fracture was 1 in 10. This patient had a thirty-six hours old compound occipital fracture. The third case concerned an alcoholic, unconscious for several hours after being assaulted with a bottle and presenting to the hospital twenty-four hours after the incident. Again medico-legal considerations were thought to explain the request for skull X-ray although the predicted chance of a fracture being

present was 1 in 100 and again a compound fracture was found. Apparently in these three cases management was not altered by the X-ray findings which means that the first case, a six week old child with bilateral temporo-parietal fractures was discharged, since from the history and examination given no other indications for admission existed. It also means that patients with compound skull fractures did not have wound toilet and suturing or prophylactic antibiotics. If true these statements are remarkable.

Of the fifteen hundred patients, 93 (6%) had skull fractures. The presence of scalp haematomas, lacerations or swelling was not significantly correlated with skull fracture nor were sex, age, a history of confusion or drowsiness, headache, visual disturbance or convulsion. Twenty-one findings were associated with more than one fracture in every ten and these associations were significant. These high yield findings included a history of unconsciousness or amnesia of more than five minutes duration, vomiting, discharge from the ears or nose, discolouration of the eardrums, "raccoon eyes," CNS signs on admission, injury considered severe, or high chance of fractures. Most (60-90%) patients with any one high yield finding did not have a fracture and no finding was present in the majority of patients with a fracture. 30% of patients with fracture had their management altered because a fracture was found, either receiving prophylactic antibiotics or surgery. The presence of at least one high yield finding as a pre-requisite for skull X-ray would have led to only one fracture being missed, and that patients therapy was unaltered by the finding of a fracture. The authors did not say if this patient was admitted and if this is not therapy. Additionally 29% of patients would not have been X-rayed. A third of patients were X-rayed for medico-legal reasons and a further half when the chance of a fracture being present was 1 in 100, in both cases such action revealed 2% of fractures. When the predicted odds for fracture were 9:1, 30% of fractures were identified, when the odds were 1 in 10, 29% of fractures were identified and when the odds were even 39% were identified. This illustrates the low accuracy of clinical

diagnosis of fracture.

De Smet, Fryback and Thornbury (356) undertook a prospective study using the high yield (HY) criteria identified by Bell and Loop. Failure to comply with the study by completing the data collection form occurred in sixty-eight patients (10% of all patients) with head injury who also had a skull X-ray - retrospective review of these patients showed that none had skull fractures. Seven (41%) of seventeen cases with skull fractures had none of the Bell and Loop criteria (confirmed by neurosurgeon), all were sixteen years old or less (4 were 1 year old or less). However the oldest of this group, a sixteen year old who had been struck by a hammer, had an expressive dysphasia on presentation which improved after surgical treatment of his depressed fracture. Except for this youth none of the seven patients had clinical clues to the presence of skull fracture. All seven were admitted, six solely and one in part, due to the findings on skull X-ray. One of the seven had a fracture communicating with the frontal sinus and prophylactic antibiotics were given. A further patient had a 3mm depressed fracture left (surgically) untreated. None of the six patients had sequelae related to their head injury. In this study only one (fracture seriously suspected) of the twenty-one HY findings was significantly correlated with the presence of a skull fracture.

The incidence of fracture in this study was 2.6% (of 662 patients) compared with 6.2% in Bell and Loop's study (348). The difference in age-distribution could explain the high number of undetected fractures, however, comparing both series by dividing them into two groups by age (under 12 and over 12 years) showed agreement between the two series in regard to patients under 12 years (i.e., no significant correlation between the high yield findings and the presence of skull fracture). Only five of seventeen patients with fractures in De Smet's series were over twelve years of age and although only one HY finding was significantly correlated with fracture in this group, the sample size was probably too small for valid comparison with Bell and Loop's study.

Soon after Bell and Loop's article, two North American studies detailing the significance of skull fractures and skull X-rays in children were published (217, 349). The study by Harwood Nash et al (217) gave a more detailed discussion of those patients with fracture from the study of 4465 children reported by Hendrick et al (134) and referred to earlier. In the epidemiological section this latter study was reviewed in more detail. 1187 children (27%) had skull fractures and 92% of these were apparent on skull X-ray, the remainder being found at operation or post mortem. An additional 257 (5.8%) had a CSF leak (36 patients) or bleeding from the middle ear (221 patients) but no fracture on SXR. 72% of the 1187 patients with skull fracture had external evidence of head injury, such evidence being contralateral to the fracture in 16% and ipsilateral in 84%. Thus in 40% with fracture there was either no external evidence of head injury (28%) or such evidence was contralateral (12%). 2.7% of fractures occurred as the result of birth injury and all were depressed. 27% of all fractures were depressed and these were often compound (46%). In all nearly one in five fractures were compound, most often via a scalp wound (79%) but also via a paranasal sinus (12%) or the middle ear (9%).

235 children (5%) developed a subdural haematoma. The risk of developing a subdural haematoma decreased with increasing age. However the incidence of subdural haematoma associated with skull fracture increased with increasing age. 6.1% of patients without fracture developed a subdural haematoma compared with 2.9% of patients with fracture. These figures are biased by the inclusion of birth injuries, 59% of subdural haematomas occurred in 0-6 month olds. Excluding the two hundred and seventy patients with birth injury does not allow this bias to be removed since the number of subdural haematomas due to birth trauma is not given. However, if all cases of subdural haematoma occurring in 0-6 month olds were due to birth trauma then the incidence of subdural haematoma in patients over six months with fractures was 2.4%, the same as the incidence in those over six months with no fracture. Also 26% of patients with subdural haematoma unrelated to birth trauma had a fracture on skull X-ray.

Extradural haematoma occurred in forty patients (1%) and sixteen of these had skull fractures. Ten out of the sixteen had a fracture on X-ray, four out of the sixteen had a fracture at operation and two had fractures at post-mortem. Incidence was nearly twice as high in the fracture group as in the remaining patients with no skull fracture. The relationship between the presence of extradural haematoma and clinical evidence of basal fracture was not delineated, nor was the same relationship with subdural haematoma. Nearly two thirds of children with extradural haematoma were over five years of age and only 8% were under one year. A half of the cases of extradural haematoma with fracture had depressed fractures and half had linear fractures. One in five cases of extradural haematoma was due to venous bleeding, and one in fourteen involved the posterior fossa (a third had occipital fractures).

About two thirds of the one hundred and forty children with severe brain damage had a skull fracture and such damage was four times as common in children with fracture (8%) as in children without fracture (2%). Skull fracture in this group was most often diagnosed at post-mortem (67/92).

The authors concluded that a skull fracture alone without clinical abnormality is of little significance and therefore such a patient does not require automatic admission. However, they allowed that the presence of a compound or depressed fracture does alter the decision for future care - 27% of their series had depressed fractures and 20% had compound fractures, not including patients with basal fractures and negative X-rays. In view of the above and the difficulty of the clinical diagnosis of fracture it is difficult to agree with their conclusion that skull X-ray at the time of admission should not necessarily be performed.

Also discussing the place of skull X-ray in head-injured children, Roberts and Shopfner (349) described five hundred and seventy patients having skull X-ray after head injury. This group was selected retrospectively and only those with adequate details

were included. The number excluded because of inadequate information was not stated. Head injury was not defined nor was admission policy. The number of head-injured children not X-rayed during the same period of time was not given either. Only unequivocal symptoms and signs were counted as present, although the proportion with equivocal information was not stated. Clinical evaluation, physical findings, radiographic findings and management were defined and categorised.

8.6% (49 children) had radiographic evidence of skull fracture and there was no significant correlation between symptoms or physical findings and the presence of a skull fracture. Of those with fracture 6% had a depressed fracture and two thirds had lacerations. 73% of patients with fracture and 13% of those patients without fracture were admitted. Thirty-three out of forty-nine children with skull fractures had no symptoms, including two thirds with depressed fractures. It does not say how many linear fractures were compound. Two patients developed subdural haematomas neither of them had a skull fracture but both had concussion and severe symptoms (as defined). One patient with a depressed fracture required surgery and the authors maintained that this patient and one other patient with a foreign body were the only patients in whom skull X-ray altered management. Without knowing the admission policy it is difficult to disagree with this statement, nevertheless patients with fractures were admitted nearly six times as often as patients without fracture and in at least some of these their management (i.e. admission) must have been determined solely by the presence of a fracture. That this is true is confirmed by the case described in Figure 1 and by the fact that half of the patients with fracture who were admitted had no symptoms, as well as by the admission of the authors who stated that detection of a fracture increased admission but did not influence 'treatment', presumably ignoring the fact that admission for observation was treatment. Similarly at least some linear fractures must have been compound (two thirds of depressed fractures had scalp lacerations and 7 out of 45 vault fractures had lacerations), in addition to those with bleeding from the ears and a fracture on

skull X-ray. Again the management must have been altered by the presence and nature of the fractures. A further thirteen patients with bleeding from the ears and negative X-rays were also admitted. They further stated that skull fractures were an insignificant manifestation of trauma and need not be detected unless there was a reasonable possibility of depressed fragments, without suggesting how this reasonable possibility could be determined. One can only agree with their conclusion that medico-legal reasons for skull X-ray are not valid.

Returning to Canada an editorial by Newman (389) denigrated the value of skull X-ray in head-injured children quoting Harwood-Nash (217), Roberts (349) and Burkinshaw (60) in support. He went on to say that many clinicians believed skull X-ray was needed for medico-legal reasons but offered no supportive evidence for this statement. He advocated the use of Bell and Loop's criteria (348). In conclusion he proposed four clinical indications for skull X-ray in head-injured children:

1. Detection of a radio-opaque foreign body
2. Detection of a clinically suspected depressed fracture
3. Detection of a fracture and/or pneumocephalus in patients with a CSF leak
4. Definition of the extent of bone damage when objective positive neurological findings are present.

However as we have seen, the clinical diagnosis of fracture in children is not easy since many have no external evidence of head injury (217), depressed fracture is often not clinically suspected (390, 391) and demonstrating such a fracture in a patient without positive neurological signs may be more important than demonstrating such a fracture in a patient with positive neurological signs (93). Demonstrating the presence of a fracture may also be important for other reasons than those quoted by Newman e.g., if it is compound.

Reporting from the same department as that from which the earlier paper by Bell and Loop (348) had originated, Phillips (360)

evaluated the use of a HY criteria list. This paper gave a detailed and lengthy description of the methods used and also included discussion of the need for such criteria and some of the results accruing. In common with many similar papers definition of head injury and admission policy were omitted. The number of skull X-rays per hundred patient visits was quoted rather than skull X-rays per hundred head-injured patients. The study was retrospective and the results reported were insufficiently detailed for the reader to independently verify the statements made by the author. Nevertheless, of patients fulfilling the HY criteria and being X-rayed, thirty-seven had positive results and in twenty-three a significant contribution to patient care was made, whereas for those having skull X-ray but not fulfilling the HY criteria, twenty-two positive reports occurred and in none of them was there a significant contribution to patient care. This suggests that more than a third of positive results are not identified by the HY criteria used. Non-compliance with the HY criteria accounted for 84% of skull X-rays during the study period.

Cummins et al (352) also undertook a study in the same hospital as Bell and Loop (348) and Phillips (360). This study was prospective and sought to evaluate Phillips high yield list for skull X-ray following trauma. Patients having skull X-ray who were not the victims of head trauma were excluded as were patients under fourteen years old. Patients with head injury who were not X-rayed were followed up to determine the outcome. Two control periods, one before and one after the study period, were included. On the whole this study seemed to meet and overcome many of the objections raised in regard to the other studies. Nevertheless head injury was not defined and neither was admission policy.

During the study period skull X-ray requests decreased significantly, although 80% of skull X-rays during this period were for indications other than those on the HY list. In addition 12% of positive HY criteria were not confirmed by checking patients notes. In a separate article referred to earlier Cummins (353) offered reasons for this non-compliance. 6.8% (sixty-five cases) of

patients X-rayed and about 4.2% of all patients with head injury had a skull fracture and a further two patients had pineal shift. The HY criteria identified 93% of the positive findings correctly - two of the five patients missed were admitted for observation, two of the five were diagnosed by retrospective review of their skull X-rays and the fifth had his general anaesthetic delayed, none of these five had adverse sequelae. The list also correctly identified 85% of patients without positive findings on X-ray. Of those patients not X-rayed, none died in the two months following their head injury, while in the 26% who were subject to review using their notes none had died of complications of their head injury or experienced post-traumatic sequelae.

A further article setting out to evaluate the efficacy of skull X-ray was published from the Eastern United States (359). This retrospective study included details of 1845 patients having skull X-ray following trauma in 1974. A total of 3154 skull X-ray examinations were carried out during the year of the study but those undertaken for reasons other than trauma (i.e., 1309) were excluded. Head injury and admission policy were not defined. Six (18%) out of thirty-three with intracranial sequelae did not have their skull X-rays reviewed. No information regarding head injuries who were not X-rayed was provided. Significant sequelae was not defined.

Out of 1845 patients, falls accounted for 37% of the injuries, road traffic accidents 28%, assaults 24%, pedestrians 3.3% and cyclists 1.1%. Pedestrians and cyclists had the highest proportion of fractures (10%) and significant sequelae (6%). There were more skull X-rays performed during the summer but no seasonal trend for fracture. The occurrence of sequelae increased in summer. 58% of those having skull X-ray were males (M/F = 1.4, rather low) but 72% of fractures (M/F 2.6) and 73% of sequelae (M/F 2.7) occurred in males. 60% were aged 0-30 years and 65% of fractures occurred in those aged 0-30 years. The age-distribution of sequelae was skewed to patients over seventy years of age. A third (614 patients) had X-ray of the cervical spine and of these, 1% had a

fracture or dislocation and 6.5% had loss of lordosis.

A skull fracture occurred in seventy-nine patients (4.3%) and significant intracranial sequelae in thirty-three (1.8%). Of the latter group, seven (21%) had skull fractures, five of these were simple fractures, one was depressed and one basal. High yield characteristics were defined as those associated with at least 10% of fractures or significant sequelae. In the history only four features produced a high yield - unconsciousness for more than ten minutes, confusion, penetrating injury and convulsions. External evidence of injury had a low predictive value for fracture and especially low for significant sequelae. Neurological deficits had a high predictive value for significant sequelae particularly, but also for skull fracture. No patient with significant sequelae had pineal shift (three quarters of pineals were not calcified).

Of patients with fractures 8.9% developed significant sequelae compared with 1.5% of those without fracture, a sixfold difference. The proportion without fracture developing sequelae is likely to be even lower since those with head injury not having skull X-ray (a number not given in the text), who could be presumed to have no fracture, would increase the denominator. Also some of those with significant sequelae and no fracture on X-ray would have a fracture clinically.

13% of patients were admitted. Nearly half of those with skull fractures were discharged, illustrating the difference between US practice and UK practice, since in the UK all patients with a fracture would normally be admitted. Two patients who developed significant sequelae were not admitted, one refused admission and the other was believed to be alright and was discharged. This latter patient would have been detected by the high-yield criteria for predicting significant sequelae. Since she had positive neurological findings it seems remarkable that she was discharged.

The author used a chi-squared test (Table 6) to show that there was no significant correlation between the presence of a skull

fracture and the development of sequelae. However, he omitted the number of patients with no fracture and no sequelae and the number of patients with fracture and no sequelae from the test. Since patients with no fracture constituted 95% of the cases, the test should be carried out with these changes, when Yates' chi-squared test shows chi-squared = 19.48 and p is much less than 0.0005, as shown below. Since the number with no fracture and no sequelae is likely to be even higher, for the reasons given above, the test would show an even more significant result regarding fracture, if this was taken into account.

		SEQUELAE		TOTALS
		+	-	
SKULL FRACTURE	+	7	72	79
	-	26	1740	1766
TOTALS		33	1812	1845

Table 2.19 Corrected Yates' chi-squared test for Masters' data
(Table 6 p. 543)

The author's conclusion that his study clearly demonstrated that skull fractures by themselves show poor predictive value for sequelae is not supported by his own evidence. His statement that absence of skull fracture does not exclude serious injury is unarguable. However to state that routine skull X-ray after head trauma and the diagnosis of skull fracture play no appreciable role in the evaluation, management or outcome of brain injury is clearly erroneous, especially since the author later said that the presence of skull fracture clearly placed the patient at a higher risk of developing intracranial haematoma and dying than did the absence of skull fracture.

The last North American study I shall consider originates again from Canada (351). A retrospective pilot study was first used to evaluate their HY criteria by applying this to 1366 patients seen during a one year period. After this period one criteria was

eliminated leaving five criteria: vomiting twice or more if the patient was more than twenty years old, decreased conscious level when examined, CSF leak or haemotympanum, palpable bony abnormality or depression, and unexplained neurological abnormality. A sixth reason was also included under the heading of 'other' which was required to be specified. These criteria were applied prospectively over a five month period to 153 consecutive patients having skull X-ray because of head injury, some severely injured patients were excluded (how many was not stated) because CT scan was performed without skull X-ray. Head injury was not defined though some aspects of admission policy were outlined in the discussion.

In the retrospective study 746 (55%) of 1366 patients had skull X-rays and 40 (5.4%) of these 746 patients had a skull fracture. If the HY criteria had been used during that period 203 (15%) of the 1366 patients would have been X-rayed and thirty-four fractures correctly identified (i.e., 15% of fractures missed). During the prospective study the proportion of head-injured patients having skull X-ray was halved and 15/16 fractures were correctly identified by the HY criteria. About a half of patients having skull X-ray during this five month period did not fulfil the HY criteria. Detection of skull fracture by using HY criteria was highly significant, assuming patients not X-rayed had no fracture.

No one criterion selected all patients with skull fracture. The absence of all five criteria would occur in 1.3% of cases with fractures. Vomiting as defined earlier was unhelpful in the diagnosis of skull fracture. Even the presence of three criteria in one individual was only associated with a 50:50 chance of fracture being present on X-ray, two criteria with a chance of 1:2.4 and one criteria with a chance of 1:7. Non-compliance with the HY criteria was most often because there was a soft tissue injury of the head (52%), only 7% were for medico-legal reasons and 5% because of a parental request. The fracture not identified by the HY criteria occurred in a three and a half month old girl who was discharged from the Emergency Room with instructions to the parents to observe her closely. She suffered no sequelae. Apart

from this patient the authors do not give information concerning outcome or complications in their patients, since the demonstration of skull fracture was their only aim.

A Finnish study retrospectively identified patients who had a skull X-ray in an A&E department during 1977 (364). 1023 patients were found and a random sample of 598 were then selected for more detailed analysis. The Male/Female ratio of this group was 1.6, the age-distribution was similar to that predicted from the epidemiological section of this thesis. Causes of injury were similar to those in British studies of admitted patients with 35% due to RTA's, 34% due to home and recreational accidents, 12% due to assaults, 5% industrial and 14% other. One in five of all patients (28% of those over 15 years) were under the influence of alcohol. More X-rays were performed in May and August and in December and also on Friday and Mondays.

91% were either not knocked out or were unconscious for upto thirty minutes, 1.2% were unconscious for more than twenty-four hours. 24% had amnesia, 60% of patients had no symptoms and 85% no neurological abnormalities. Eighteen (3.1%) out of five hundred and eighty-seven had bleeding from the ears but there were no cases of CSF leak. 41% had a scalp wound (only a fifth were lacerations). Nine (1.5%) of the five hundred and eighty-seven developed intracranial haematomas, in 58% there was no clinical evidence of brain injury, 39% had concussion and 1.3% had cerebral contusion. 53% were discharged after examination and 47% were observed in A&E, especially those having consumed alcohol. Overall 57% were discharged home, 36% were admitted to wards 5.4% were admitted to ITU and 1.7% were transferred to another hospital.

Forty-nine patients (8.2%) had a skull fracture on X-ray, four of these were diagnosed clinically prior to X-ray. Fractures were four times as common in patients with more severe brain injury and less common in patients with concussion only. Four variables were significantly associated with skull fracture - amnesia, unconsciousness for more than thirty minutes, scalp wound and

haematoma combined and a decreased conscious level. If all four were absent a fracture on X-ray occurred in 3% of such cases, but it was not stated how many fractures occurred if all four were present. The presence of one variable indicated a one in seven chance of fracture. 30% of patients with fracture were discharged from A&E and the presence of a fracture did not influence duration of stay (cf: MacMillan (25)) although it did prolong time off work. The authors concluded that the four HY variables should be used to reduce skull X-ray requests even though they would lead to missing one in five fractures. They did not correlate the presence of a fracture with sequelae or complications.

Reporting from Australia de Campo and Petty (354) investigated the usefulness of SXR in head-injured patients. They accomplished this by retrospectively analysing 1053 A&E patients with "possible" head trauma presenting during a twelve - month period. Whether or not these patients were consecutive is not stated. Head injury was not defined nor was admission policy. Facial injuries were excluded. Six positive findings on SXR were defined, as were seven clinical findings which might suggest SXR would be beneficial, i.e., a high-yield list. The medical records of one patient with a skull fracture were unavailable. The number of patients with head injury who were not X-rayed was not given. Twenty-four patients (2.3%) had positive radiological findings - 23/24 were skull fractures and 1/24 had pneumocephalus. Of the twenty-three patients with fractures available for study, nine had positive clinical findings as defined, all were 'severe' head injuries and all were admitted and required additional neurosurgical care. (Seven of the nine required operation and two had prophylactic antibiotics) Two thirds of these patients had their care influenced by the X-ray findings (two depressed fractures, two compound vault fractures and two basal fractures). The remaining fourteen patients had none of the 'defined' clinical criteria indicating skull X-ray might be beneficial. Six were admitted for observation and one of these subsequently developed an intracranial haematoma, having been admitted partly because of a positive skull X-ray. Of the five remaining patients, four were admitted because

of associated injuries and one because of a history of brief unconsciousness and the presence of a skull fracture. Eight of fourteen patients with negative clinical criteria and skull fracture were discharged, four had fractures undetected by the A&E staff, one was lost to follow-up and the remaining seven, who were followed up, were well.

Overall the authors stated that in only six out of twenty-three cases did radiological findings initiate change in treatment. Not enough information is given to evaluate this statement e.g., four patients known to have fractures on skull X-ray were discharged from A&E - was this because the presentation was late or was it for another reason. Also five patients were admitted for observation only, which the authors do not seem to recognise as a form of treatment, notwithstanding that in four cases associated injuries were the reason for admission and in only one case was the presence of a skull fracture in part the reason for admission. Four of the twenty-three had surgical treatment for the evacuation of intracranial haematomas presumably no patients with normal skull X-rays had intracranial haematomas, yet the authors state that "a positive X-ray finding..... is no guide to the presence or extent of intracranial injury", and the corollary "a report stating normality does not exclude a fracture, nor is it a guide to the presence or extent of intracranial injury". Neither of these statements is supported by their own results as we can see from the tables below:

		FRACTURE		TOTALS
		+	-	
INTRACRANIAL	+	4	0	4
HAEMATOMA	-	19	1030	1049
TOTALS		23	1030*	1053

CHI-SQUARED = 136.8, p much less than 0.0005

(*Includes 1 with fracture lost to follow up)

Table 2.20 Relationships between skull fracture and intracranial haematomas DE CAMPO and PETTY (354).

		FRACTURE		TOTALS
		+	-	
ADDITIONAL	+	10	0	10
NEUROSURGICAL				
CARE	-	13	1030	1043
TOTALS		23	1030*	1053

CHI-SQUARED = 407

p much less than 0.0005

(*Includes 1 with fracture lost to follow up)

Table 2.21 Relationship between skull fracture and additional neurosurgical care, DE CAMPO and PETTY (354).

Their statement that patients who have no clinical criteria do not require a skull X-ray but instead should be observed for a time in casualty is, for practical purposes, impossible to adhere to, even if it were justified, as is their suggestion of reviewing such patients the following day.

In summary, therefore, we can say that at best the clinical diagnosis of skull fracture is imprecise, particularly in children. In the majority of British A&E departments this means that the diagnosis is most often made on skull X-ray, although about 40% of A&E patients with head injury do not have skull X-rays. That establishing the presence or more commonly the absence of skull fracture is important, is demonstrated by the following considerations in the light of the uncertainty of the diagnosis being made in any other practical way (i.e., clinically) in the majority of cases.

1. 75-89% of patients who develop an extradural haematoma have a skull fracture on X-ray, of those without fracture 91% are less than thirty years old.
2. In a mildly injured patient the presence of a fracture on X-ray increases by 400 times the likelihood of the

development of an intracranial haematoma.

3. In a stroke victim or a drunken patient the presence of a fracture increases by 20 times the likelihood of an intracranial haematoma developing.
4. In a deteriorating patient the presence of a fracture on skull X-ray may be the only lateralising evidence or may indicate an unusual site, e.g. the posterior fossa, for an intracranial haematoma.
5. Skull X-ray may be the only way of diagnosing a depressed fracture and avoiding the complications due to infection and intracranial haematoma developing.
6. In a small proportion of patients (10% of whom appear mildly injured) intracranial air may be found and appropriate treatment instigated, so avoiding complications.
7. The presence of a fracture on skull X-ray may provide one method of selecting patients at risk for CT scan where this investigation is scarce.
8. The absence of a fracture on skull X-ray in the presence of a compatible clinical picture may indicate the diagnosis of white matter shearing injury.
9. Exclusion of a fracture by skull X-ray may allow appropriate pursuit of alternative diagnoses in patients with an altered conscious level.
10. Serendipity findings may be apparent - tumour calcification, aneurysmal calcification.
11. Absence of a fracture in a mildly injured patient may allow that patient to be discharged more safely.

12. Findings such as a sphenoid fluid level or a fracture underlying a laceration indicate that a fracture is compound and the need for appropriate management.
13. Legal problems may be obviated.
14. Skull X-ray for varied reasons may permit the doctor dealing with head-injured patients to reach a correct decision.
15. Pineal shift may be evident.
16. The presence and site of radio-opaque foreign bodies can be determined.

All the attempts by radiologists to limit skull X-ray have shown that using HY criteria does decrease the number of skull X-ray examinations and with varying degrees of accuracy selects groups of patients more likely to have a fracture. When the statistical significance of skull fracture in relation to sequelae and complications has been correctly determined from this data the presence of a fracture has proved highly significant. Their conclusion that demonstrating the presence of a fracture is futile is therefore erroneous. No one criterion is associated with all fractures and even when many criteria are present the chances of a fracture being present may still be 50/50 or less. For the clinicians dealing with patients one at a time, these HY criteria proved to be of little value. This is borne out by the degree of non-compliance with HY criteria where these are applied. This non-compliance is not done for spiteful or perverse reasons, but for complex ones. Skull X-ray and skull fracture are only one aspect of patient management and not the only consideration. Showing positive findings to be scarce does not justify concluding such findings are valueless. It would be better for radiologists to ensure adequate films, correctly interpreted so as to allow A&E staff to be more certain in their management of head-injured patients.

One of the many tricky decisions relatively inexperienced doctors working in A & E departments have to make is which head-injured patients to admit. Often this difficulty is compounded by an individual patient's recent consumption of alcohol and the doctors own rather hazy recollections of anecdotes concerning patients sent home from A & E only to die from the effects of an intracranial haematoma. Most often no definite policy exists for selecting which patients should be admitted for observation, instead, a rather nebulous set of criteria operate. Both undergraduate and post-graduate teaching on this aspect of the management of head-injured patients is deficient, surprising in view of the proportion of surgical admissions due to head injury. Negative attitudes of the admitting surgical house-officer often aggravate the situation, head-injured patients generally being viewed in a similar light to patients admitted to medical wards following parasuicide. Therefore it behoves each accident unit in conjunction with general surgical and neurosurgical colleagues to formulate a policy for the admission and transfer, when necessary, to the regional neurosurgical unit of patients with head injury.

84% of patients admitted to Scottish hospitals following head injury were talking normally and 97% obeyed commands (25). The same authors reported 44% were fully recovered from an episode of unconsciousness, 20% had neurological symptoms and/or signs, while the remaining 36% had neither. Virtually all these patients who are apparently well on admission are admitted because they are considered to be at an increased risk of developing complications. For practical purposes the feared complication most likely to develop in an apparently well patient is extradural haemorrhage. Such fear requires the admission of perhaps two hundred thousand patients per year in this country, by far the majority of these being apparently well on admission. This is an enormous financial investment since hospital admission now costs more than £80.00 per day (73). In this section I hope to define the level of risk and identify those factors which will select patients with an increased

risk of developing complications, particularly extradural haematoma. However I will begin by examining the current admission policy and attempt by a consideration of published work to determine whether this policy has succeeded.

It is probably true to say that the aims of admitting head-injured patients are:

1. To allow definitive or supportive treatment of patients, who on initial presentation clearly merit such action, e.g. patients with compound depressed fractures or a depressed conscious level.
2. To allow the early detection and treatment of complications in patients who on initial presentation appear well but who are considered to be at increased risk.
3. To allow the treatment of other injuries or conditions which are independent of any head injury.

The first of these aims is only applicable to a very small proportion of patients, while the latter aim, also applicable to only a small proportion of patients, is separate from the head injury. The overwhelming majority of admitted patients fall into the second category.

No admission policy can hope to lead to the admission of all patients who subsequently develop complications since not all patients may initially seek medical advice or exhibit features defined in the policy. In Britain the undermentioned admission criteria are those most commonly employed:

ABSOLUTE INDICATIONS

History of unconsciousness
History of amnesia
Any neurological sign
A skull fracture
Post-traumatic convulsions

RELATIVE INDICATIONS

Symptoms
Recent alcohol consumption

It is assumed that application of these criteria coupled with close observation will lead to early diagnosis and treatment of complications thus reducing morbidity and mortality. If successful this would mean that only 'inevitable' mortality and morbidity occurred, such being due to the nature of the primary brain damage. The corollary of this is that mortality and morbidity due to preventable (secondary) events should be minimal. I will now consider each of the absolute admission criteria in turn and appraise each against the background of the previous sections of this review and in terms of their sensitivity, specificity and indication of relative risk.

The commonest single reason for admission following head injury is a history of initial unconsciousness (16, 25, 53, 73). A period of amnesia related to the time of injury is allied to this and the former may often be inferred, in the absence of independent witnesses, from the latter. Accordingly these two criteria will be considered together, although specific details will refer only to a history of unconsciousness. In Scotland 44% of head injury admissions of all ages were fully recovered from an initial period of unconsciousness and 20% had neurological symptoms and/or signs (25). Presumably some of this latter group had been initially knocked out but on presentation were symptomatic only. All of the patients described by Barr and Ralston (53) had a history of unconsciousness, whereas in an adult series 77% had been unconscious for less than thirty minutes (16). In children a history of initial unconsciousness was less common, varying from 32% (61) to 36% (62). For admissions of all ages therefore, it would be reasonable to assume that about 60% of admissions had a history of initial unconsciousness but were either fully recovered or were only symptomatic. In patients who developed extradural haematoma, between 16% (248) and 46% (225) were not initially knocked out, while in children this proportion may be two thirds (228) and for patients with pure supratentorial haematoma 41% (233). In the section on extradural haematoma, I suggested a consensus view indicated a quarter of such patients had no initial period of unconsciousness. If we consider a population of one hundred

thousand head injury admissions and assume that the incidence of extradural haematoma is 0.2% (250) and further assume that a quarter of patients with extradural haematoma were not knocked out initially and that 60% of admitted patients were knocked out initially, we can construct the following table to illustrate the relationship between the two.

		HISTORY OF UNCONSCIOUSNESS		TOTALS
		+	-	
EXTRADURAL	+	150	50	200
HAEMATOMA	-	59850	39950	99800
TOTALS		60000	40000	100000

Table 2.22 Relationship between extradural haematoma and a history of unconsciousness

Although a highly significant relationship exists between a history of initial unconsciousness and the development of extradural haemorrhage ($\chi^2 = 18.17$, p less than 0.0005) the relative risk between patients with and without a history of unconsciousness is 2.0. Approximately three hundred and ninety-nine patients with a head injury, who experienced an initial period of unconsciousness, would be admitted for every one patient initially knocked out who subsequently developed an extradural haematoma. Despite the large numbers admitted purely on the basis of this criterion, one in four cases of extradural haematoma would be missed. Viewing a history of unconsciousness as a diagnostic test for extradural haematoma, the sensitivity of this test according to table 2.22 would be 0.75 and the specificity would be 0.40. An ideal test which was invariably correct would have a Youden's index = 1, whereas a valueless test would have an index = 0 (400). For the above results in patients with extradural haematoma the index for the test "history of unconsciousness" is 0.15 i.e. very low. If the proportion in the test were confined to patients who had made a full recovery from an initial period of unconsciousness the diagnostic value would be even lower.

Jamieson and Yelland (271) reported that 45% of all patients with any type of subdural haematoma were not rendered unconscious initially. For patients coming to operation within twenty-four hours of injury this proportion is likely to be considerably lower, especially since only 2.4% of such patients were awake when first admitted to hospital in one series (305). If the overall incidence of subdural haematoma is 0.6% of admissions and half of these occur in the first seventy-two hours and if 80% of such patients have an initial period of unconsciousness, then two hundred and forty-nine patients with an initial period of unconsciousness would be admitted for every one patient with acute subdural haematoma who was initially knocked out. Applying these same assumptions to our population of one hundred thousand head injury admissions a highly significant relationship between a history of unconsciousness and the development of acute subdural haematoma would be shown (p less than 0.0005). However the relative risk would be 2.7, the sensitivity of this test would be 0.80, the specificity 0.40 and the diagnostic value (Youden's index) 0.20. Similarly the data from Jamieson and Yelland's series (339) of surgically treated cases of intracerebral haematoma indicates that for all such cases, irrespective of the time of onset, about half were not initially knocked out. Assuming the same overall incidence as for extradural haematoma then five hundred and ninety-nine patients with an initial period of unconsciousness would be admitted for every one patient admitted who developed an intracerebral haematoma.

In the series of admitted patients discussed by Barr and Ralston (53) 49% were confused, stuporose or comatose on admission. The conscious level was not recorded in 23% of patients described by Steadman and Graham (45), 56% were conscious and the remaining 21% were drowsy or unconscious. Rowbotham et al (42) reported 25% of patients were semi-conscious or comatose. More recently in Scotland, 84% were talking normally on admission and 97% were obeying commands (25). In another series, 86% of adult admissions had no symptoms or signs related to their head injury (16). An impaired conscious level on admission occurred in 29% of children,

while in the same series 16% had other neurological signs (62). These variations in the incidence of neurological signs are largely the results of differences in patient selection. A fair estimate might be that 25% of admitted patients have neurological signs on presentation. Of patients with extradural haematoma about one quarter are unconscious throughout (see section 2.3) whilst other signs obviously may be present on initial examination, most authors do not differentiate the appearance of such signs with regard to time. Assuming approximately 40% of patients who develop extradural haemorrhage have signs on presentation and applying this to the population of a hundred thousand admissions in the same way as described above we can construct the following table:

		NEUROLOGICAL SIGNS		TOTALS
		+	-	
EXTRADURAL	+	80	120	200
HAEMATOMA	-	24920	74880	99800
TOTALS		25000	75000	100000

Table 2.23 Relationship between extradural haematoma and neurological signs

Again the relationship between the presence of neurological signs on admission and the development of extradural haematoma is highly significant (chi-squared = 23.25, p less than 0.0005). The relative risk is 2.0, the sensitivity is 0.40, the specificity 0.75 and Youden's index is 0.15. Three hundred and twelve patients with neurological signs will be admitted for every one patient with neurological signs who develops an extradural haematoma.

Turning now to patients with acute subdural haematoma, in one series only 2.4% of such patients coming to operation in the first twenty-four hours were awake when first admitted (305). Of the acute cases described by McKissock et al (281) none had a normal conscious level on admission, whereas in Hernesniemi's series (308)

13% were alert when first admitted and in Harris's series (326) 15% were conscious on admission. Assuming 90% of patients with subdural haematoma diagnosed within seventy-two hours have neurological signs on admission then ninety-two patients with neurological signs will be admitted for every one such patient who develops an acute subdural haematoma. The relationship between the two is very highly significant ($\chi^2 = 674.6$, p much less than 0.0005). The relative risk is 28, the sensitivity 0.90, the specificity 0.75 and Youden's index 0.65.

Approximately 7% of patients admitted following head injury have a skull fracture evident radiologically (25). The majority of patients who develop extradural haematoma have a skull fracture or diastasis on X-ray varying from 75% (229) to 89% (228). Most of those without a fracture are children or young adults (250, 261). Assuming 80% of patients with extradural haematoma have a radiologically evident fracture, then forty-three patients with a fracture on skull X-ray will be admitted for every one such patient admitted who later develops an extradural haematoma. There is a highly significant relationship between the two factors as determined by constructing a contingency table in the same way as previously and based on the foregoing assumptions ($\chi^2 = 1629.2$, p much less than 0.0005). The relative risk of a patient with a skull fracture developing an extradural haematoma is 54. The sensitivity of skull fracture as a diagnostic test for extradural haematoma is 0.80, the specificity is 0.93 and Youden's index is 0.73.

In McKissock's series (281), 55% of patients with acute subdural haematoma who were X-rayed, had a fracture evident on skull X-ray. In cases coming to operation within twenty-four hours 68% of those X-rayed had a fracture (313) and of all cases in Jamieson's series (271) 48% were radiographed and 64% had a skull fracture. Assuming 60% of cases of acute subdural haematoma coming to operation within seventy-two hours have a fracture on X-ray then thirty-eight patients with fracture on X-ray will be admitted for every one such patient who develops an acute subdural haematoma. A

highly significant relationship exists between the two (chi-squared = 1947.1, p less than 0.0005). The relative risk is 20.4 but the sensitivity is 0.60, the specificity 0.93 and Youden's index 0.53.

For patients with intracerebral haematomas, 59% of those X-rayed had a skull fracture (339). Again assuming the incidence of intracerebral haematoma is the same as that of extradural haematoma, then fifty-eight patients with skull fracture will be admitted for every one such patient who develops an intracerebral haematoma. The relationship is highly significant (chi-squared = 641.2, p much less than 0.0005), the relative risk is 19.4, the sensitivity 0.59, the specificity 0.93 and Youden's index is 0.52.

Patients who experience early post-traumatic epilepsy are admitted largely because of the unpredictability of subsequent events and not because of the predictive value of convulsions in regard to later complications. Jennett (23, 24) suggested that early epilepsy occurred in 5% of head injury admissions. More recently, MacMillan et al (25) recorded early epilepsy in only 1% of admissions. The latter series, sampling the whole of Scotland, was probably a less selected series than that of Jennett. This difference in selection occurred because of the admission of more minor head injuries in the later Scottish series which covered the year 1974. In the Oxford series, post-traumatic intracranial haematomas occurred in 22% of cases of early epilepsy (24). Only 30% of cases with early epilepsy had their first convulsion within one hour of injury and a further 30% in the next twenty-three hours (24). The majority of cases of early epilepsy who developed intracranial haematomas were already seriously ill and the lesion was subdural or intracerebral. One in ten cases of extradural haematoma developed early epilepsy, but in a third of these convulsions did not begin until after evacuation of the clot. Only a small proportion (2%) of cases with early epilepsy had developed an extradural haematoma by the time of their first fit. In this small group of patients other signs were always present, pointing to the diagnosis of extradural haematoma (24, 401).

Comparisons of the relationships between extradural haematoma and the major absolute indications for admission and between subdural haematoma and admission criteria are shown in Tables 2.24 and 2.25. In all cases the relationship between any

REASON FOR ADMISSION	RELATIVE RISK	SENSITIVITY	SPECIFICITY	YODENS INDEX
HISTORY OF UNCONSCIOUSNESS	2.0	0.75	0.40	0.15
SKULL FRACTURE ON X-RAY	54	0.80	0.93	0.73
NEUROLOGICAL SIGNS	2.0	0.40	0.75	0.15

Table 2.24 Statistical indices of the relationship between extradural haematoma and admission criteria.

criterion and any type of intracranial haematoma is highly significant (p less than 0.0005). However, the most valuable criterion for patients with extradural haematoma is the presence of

REASON FOR ADMISSION	RELATIVE RISK	SENSITIVITY	SPECIFICITY	YODENS INDEX
HISTORY OF UNCONSCIOUSNESS	2.7	0.80	0.40	0.20
SKULL FRACTURE ON X-RAY	20	0.60	0.93	0.53
NEUROLOGICAL SIGNS	28	0.90	0.75	0.65

Table 2.25 Statistical indices of the relationship between subdural haematoma and admission criteria.

a fracture on X-ray and for patients with subdural haematoma is the presence of neurological signs followed closely by the presence of a fracture on X-ray. In both instances a history of initial unconsciousness is a poor diagnostic test. The value of skull

fracture in selecting patients for admission would be shown to be greater if patients diagnosed as having a fracture clinically, at operation or post-mortem were included in the contingency tables. Whilst the assumptions made regarding the proportion of patients knocked out are likely to be fairly accurate, those regarding patients with neurological signs seem likely to underestimate the proportion of patients with haematoma and neurological signs and overestimate the proportion of all admitted patients with signs. Both these errors would tend to undervalue this criterion as a method of selection of patients for admission. This method of assessing the value of the absolute indications for admission treats each factor in isolation even though in practice they are interrelated. However, despite its drawbacks it does indicate that the commonest single reason for selecting head-injured patients for admission, i.e., (a history of) initial unconsciousness, is a poor indicator of risk. Discarding this criterion from the list of absolute indications for admission would drastically reduce the number of head injury admissions with only a small increase in risk.

Relative indications for admission are used because they may be predictive of complications, may confuse other indicators or else in their own right justify symptomatic treatment. The majority of patients who develop extradural haematoma and who are not initially knocked out, or who have no skull fracture on X-ray, are children (228, 250, 261). For these reasons prediction of complications in children is more difficult and one is therefore more likely to admit children because they exhibit symptoms than is the case in adults. However, in the paediatric series reported by Hendrick et al (134) vomiting and headache were not significant of any particular pathology, although vomiting was twice as common in children with extradural haematoma as in the general series and only half as common in cases of brain damage. The problems caused by recent alcohol consumption have already been mentioned in section 2.1.6 (77, 78, 79). Because of the difficulty in assessment occasioned by the effects of alcohol, recent alcohol consumption is a relative indication for admission. Some assistance in this regard may be gained from estimation of the blood alcohol level, although

it is wisest to attribute any neurological signs in a head-injured patient, known to have been drinking, to the effects of the head injury and admit the patient for observation and investigation.

In McKissock's series (281) only 11% of patients with acute subdural haematoma complained of headache, however, in many patients their conscious level was depressed and they would have been unable to complain of any symptoms. Headache is much commoner in patients with chronic subdural haematoma (281, 289, 309, 317) and less common in subacute cases (281). Vomiting occurred almost equally in all types of subdural haematoma in McKissock's series (281), being present in 30% of subacute and chronic cases and 24% of acute cases. Approximately a third of patients with extradural haematoma in McKissock's series (228) complained of headache and in Jamieson's series (225) more than half of those patients conscious at the time of operation complained of headache. Vomiting was a prominent symptom in a little over a fifth of patients with extradural haematoma in one series (228) and two-thirds of these patients were under fifteen years old. Comparing the incidence of symptoms in admitted patients with those in patients with acute complications overstates the case and more properly the comparison should be between the incidence of such symptoms among A&E attenders and among patients with complications when the non-specific nature of such symptoms will be more readily apparent.

Summarising so far, it is reasonable to suggest that discarding a history of initial unconsciousness or of amnesia from the admission criteria would reduce admissions without lessening the effectiveness of the policy in selecting patients who later developed complications, particularly extradural haematomas.

If the admission criteria at present employed in the United Kingdom are succeeding in their aims, then delay in diagnosis should occur infrequently and relatively few patients with currently treatable complications should die unoperated. As we have seen in the earlier sections dealing with post-traumatic intracranial haematoma, there is general agreement that one of the most important

causes of an adverse outcome is delay (78, 190, 191, 216, 224-229, 233, 248, 249, 255, 263, 402-405). In their series dealing with cases of pure supratentorial extradural haematoma, Mendelow et al (233) clearly showed how delay increased morbidity and mortality. The mean delay in those who died was 15.7 hours compared with 1.9 hours in good quality survivors. Mean total delay during the later period (1968 to 1977) was significantly less than during the earlier period (1951 to 1960) but was still 2.4 hours. The mean hospital delay between the two periods was not significantly different being 8 hours in the earlier period and 1.4 hours in the later period.

Another indirect method of assessing delay is by determining the proportion of patients with a lucid interval since in some of these patients completion of the lucid interval can only arise because of delay in diagnosis. Thus in Jamieson's series (225) the surgical mortality from extradural haematoma was 16% and 12% of all cases showed a lucid interval while in four other series (211, 212, 228, 249) the incidence of lucid interval was greater, as was the mortality. Mortality is related to conscious level at the time of operation (225) and delay will lead to a lowering of the conscious level and an increase in mortality.

Delay has also been examined by Galbraith (78) who reported that more than a third of patients with post-traumatic intracranial haematoma transferred to the Glasgow Regional Neurosurgical Unit had been deteriorating for more than twelve hours in the referring hospital. Furthermore in two-thirds of these patients delay was due to misdiagnosis, patients being labelled as stroke victims or drunks. In these cases the presence of a skull fracture was overlooked as a pointer to the correct diagnosis. A fracture was also commonly present in the remaining third of patients in whom no explanation for the deterioration in conscious level was made at the referring hospital.

In 1951 James and Turner (264) showed that nearly three times as many cases of extradural haematoma were known to the coroner as were treated in hospital. In the case of subdural

haematoma no acute or subacute cases were treated in hospital yet forty-eight cases of acute and nine cases of subacute subdural haematoma were known to the coroner. Moreover although eight cases of chronic subdural haematoma were treated in hospital, eleven cases were known to the coroner and for intracerebral haematoma, eight cases were treated in hospital and one case was known to the coroner. Altogether eighteen cases of intracranial haematoma were treated in hospital and eighty-five cases were known to the coroner, all the latter died unoperated. Other authors have also found a significant number of cases first coming to light at post-mortem (78, 289, 318). In 1976 Galbraith (78) reported 22% of patients who developed an intracranial haematoma after admission (for observation) to a teaching hospital died with the haematoma unrecognised during life. Again misdiagnosis either as a drunken state or a cerebro-vascular accident occurred, and the majority of both groups were known to have a skull fracture.

Several authors have looked for preventable factors in patients with head injury who died after admission to hospital. Reilly et al (406) reported that 75% of patients whose initial head injury was not overwhelming, in that they were able to talk at some time after the injury, but who subsequently died, had a significant intracranial haematoma. In most of these patients death was due to brain shift and herniation with secondary brain-stem damage. Rose et al (191) described a larger series of one hundred and sixteen patients who had talked and died. They found one or more avoidable factors had occurred in 74% of their cases and that such an avoidable factor certainly contributed to death in 54% of cases. Delay in the treatment of an intracranial haematoma was the most common avoidable factor, occurring in 62% of all cases and definitiely contributing to death in 43%. Such delay occurred prior to arrival at hospital in a fifth, in the A&E department in 11%, in the primary surgical ward in 47% and in the neurosurgical unit in 22%. Similar avoidable factors also occurred in 40% of an additional fifty patients who died without having talked after injury. Jennett and Carlin (21) discussed preventable mortality and morbidity following head injury in all its aspects and re-iterated

the evidence provided by Rose et al. In a study similar to that of Rose and his colleagues, Jeffreys and Jones (190) identified avoidable factors definitely contributing to death in 46% of a hundred and seventy patients. One quarter of these patients talked and died and in one third of all cases delay in operation or failure to evacuate an intracranial haematoma occurred.

On the basis of the foregoing discussion it is clear that the current management of head-injured patients is poor, in that delay in diagnosis and treatment of remediable lesions too often occurs and that the incidence of preventable mortality and morbidity is too high. Many authors have argued for a re-appraisal of the present admission policy (16, 18, 21, 51, 55, 73, 89, 190, 191, 361, 393, 407-413).

The current practice of admitting large numbers of patients who are apparently well is probably counter-productive. It is not difficult to accept that such a policy tends to blunt the sensibility of those responsible for the observation of these patients. Furthermore, junior doctors, whose time is often at a premium, are often resentful of dealing with head injuries since they know that the overwhelming majority of such patients will be discharged within hours or days in a condition no different to that on admission. Expecting relatively inexperienced doctors and nurses to recognise slight changes in a patients condition at an early stage is hardly reasonable when such early signs of deterioration occur against a background of overwhelming normality. These factors mitigate against optimal management. In fact patients with head injuries are viewed by junior doctors and nurses in much the same light as patients who have taken overdoses i.e., routine, unimportant, wasteful of their time and uninteresting. As a result such patients receive sub-optimal management and opportunities for successful early treatment are lost, never to be retrieved. Thus delay, the commonest cause of preventable mortality and morbidity, is encouraged by the current policy.

Jennett (410) has stated that were his son to sustain a

head injury with initial loss of consciousness, then so long as he was fully conscious and orientated and a skull fracture had been adequately excluded, he would not wish his son to be admitted. The same author, as well as others from Glasgow have expressed this view in other papers (16, 18, 21, 73, 408, 409, 411). Such a policy would drastically reduce the number of head injury admissions. Moreover it would reflect the available evidence which indicates that a history of initial unconsciousness is of poor discriminant value and, by promoting large numbers of admissions, encourages delay. The presence of a skull fracture is highly correlated with the development of intracranial haematomas as indicated earlier. Galbraith (250) and Galbraith and Smith (414) as well as Mealey (261) have shown that extradural haematoma without skull fracture is most common in children (250, 261, 414) and that most cases of subdural haematoma without skull fracture are over forty years old (414). Galbraith (250) was able to state that an adult hospital admitting a thousand head injuries a year could expect an extradural haematoma to occur in a patient over thirty years of age without a skull fracture only once every thirty years. Since some patients without a skull fracture could be expected to have significant symptoms or signs the likelihood of such an event occurring is actually less than this. Thus Galbraith and Smith (414) recorded fifty-seven (19%) of three hundred and seven cases of post-traumatic intracranial haematoma evacuated within fourteen days had no skull fracture. However forty-three of these cases without fracture had symptoms (severe headache or vomiting) or signs immediately after injury. The remaining fourteen patients had none of these features, five were children under thirteen years old who developed symptoms and signs within forty-eight hours. Five more patients were over sixty years old and developed symptoms and signs more than forty-eight hours after injury, i.e., after the average duration of stay for patients admitted for observation following head injury. The four remaining patients were aged thirty to fifty years and developed symptoms and signs within forty-eight hours. The orthodox admission policy currently used in the U.K might have led to the admission of one of these four patients who had fallen whilst under the influence of alcohol, but in whom details of loss of

consciousness and amnesia were unknown; he did not have symptoms or signs. None of the other three patients had either absolute or relative indications for admission immediately after their injury whichever policy was applied. Two did however have signs at the time of their admission to hospital, eight and twenty-four hours after injury, and were admitted. The third patient was admitted at the time of his initial presentation even though no apparent indication for admission existed. Contrarily this latter patient was the only one of the four adults to die. Thus, introduction of the more selective policy would not lead to any adults, who developed symptoms and signs of a haematoma within forty-eight hours, but who had no indication for admission immediately after injury, being discharged, who would NOT also have been discharged according to the policy currently in use. Based on the three adults mentioned above and assuming all three presented immediately after injury and were sent home, both the current and more selective policies would lead to the discharge of such a patient once every twelve years from a population of one million. For a hospital admitting one thousand head injuries of all ages each year, such an event would occur once every thirty-three years, however on the evidence of this paper the actual risk would be much less than this. The position regarding children is much more difficult to resolve. The reasons for admission of the five children without fracture, symptoms or signs in this study were not given. However even if the more selective policy led to all these five children being sent home initially, one such case would arise only once every 7.2 years in a population of one million or about once every twenty years for a hospital admitting one thousand head injuries of all ages per year. Furthermore discharging such a patient at his first attendance would not necessarily result in his death when subsequent deterioration occurred. The risk attributable to those cases developing after forty-eight hours in elderly patients cannot be accurately determined from this paper since which of the five patients were admitted and why was not given. If all five had initially been discharged the risk would be the same as for children i.e., once in twenty years. However owing to the gradual development of symptoms and signs in this group immediate admission

would not have conferred any benefit as regards the diagnosis or treatment of their haematoma. In a mildly injured patient the finding of a skull fracture increases by four hundredfold the likelihood of an intracranial haematoma developing (93). Similarly in a comatose patient thought to be drunk or to have suffered a stroke, the presence of a skull fracture increases the likelihood of finding an intracranial haematoma by about twenty times (93). A consideration of the previous sections of this review will re-enforce belief in the value of demonstrating or more commonly excluding the presence of a skull fracture in a patient with head injury.

Any patient with one or more of the following: skull fracture, neurological signs or early epilepsy, should be admitted for close and critical observation. Patients without any of the foregoing but who are symptomatic or who have been drinking, and children, may need to be admitted, each case being judged on its merits. This policy is more reasonable than the current practice and is in keeping with that proposed by the authors already referred to. Such a policy was introduced in Nottingham in 1978 by Weston (51). The hospital concerned dealt only with adult cases. As a result of the new admission policy head injury admissions were reduced to about half their previous level without any serious complications developing or patients dying as a result of the policy. One head injury death did occur outside hospital in a patient discharged from A&E. This death resulted from an extradural haematoma occurring in a young man, who had a hairline parietal fracture overlying the haematoma. This patient was not X-rayed on initial attendance and both he and his friends lied both about the cause of injury and his subsequent conscious level. History and examination in this case would not have led to his admission by orthodox criteria, unless he had been X-rayed and the fracture had been identified.

By manipulating collected data on patients admitted according to current practice, other British authors have discussed alternative admission policies (73, 361, 407). In the Royal College

of Radiologists report (361) the costs and benefits in the same group of patients were compared when analysed according to current practice and according to practice if skull X-ray was unavailable. A saving of about £11,000 was calculated to occur if the latter method was employed. This paper has already been discussed and criticised in the section on radiology (section 2.5). Briefly the study group was confined to only those patients with head injury who were referred for skull X-ray. The substantial number of patients with head injury not referred for skull X-ray were excluded from the analysis. Also the assumption was made that patients admitted but not X-rayed stayed an average of 1.3 days compared with an average of 1.4 days for current practice. No reasonable explanation for this difference was made. If the average length of stay in the two groups was the same, the projected saving would be £4,419. Since one patient who developed an intracranial haematoma (and had a skull fracture) would have been discharged any amount saved would have been eaten up by the legal costs occasioned by this disaster.

Jones and Jeffreys (407) also compared the effect on outcome of various simulated admission policies. Six options were considered and five options resulted in at least some patients with severe intracranial injuries being sent home. Current practice was the only option that did not result in severely injured patients being discharged, however verification of this fact was not sought, e.g., by checking post-mortem reports or establishing if patients initially sent home were recalled when previously undiagnosed fractures were identified by radiologists. Also only patients admitted for observation were studied, thus introducing bias into the results since patients with compound and/or depressed fractures, neurological signs or serious intracranial injury were excluded. None of the policy options corresponded to that advocated by Jennett and his colleagues or by Weston.

Mendelow et al (73) described fourteen hundred and forty-two patients admitted to the head injury unit at Edinburgh Royal Infirmary in 1979. Secondary referrals accounted for one in ten of these cases. Epidemiological data concerning the twelve

hundred and ninety-seven direct admissions were similar to those reported by SHIMS (25) except that fewer children and fewer patients with multiple injuries were included. Subdivision of patients into five groups was undertaken. Eight hundred and sixty-five patients (67%) who were direct admissions had no skull fracture, no focal signs, no headache or vomiting, but did have a history of initial unconsciousness. An intracranial haematoma developed in one (0.12%) of these patients. Of all cases, including secondary referrals, fifty-six (3.9%) developed intracranial haematomas (7 extradural and 49 intradural) and forty-five of these were not alert and orientated on admission, four of the remaining eleven patients were secondary referrals and had a fractured skull. The reasons for admission in the remaining seven cases were: focal signs (2), headache (2), vomiting (1), skull fracture (1) and a history of unconsciousness (1). Six of these cases would have been admitted according to the more selective policy already referred to. In order to identify the one patient with only a history of being knocked out, eight hundred and sixty-four other patients were admitted and the cost of identifying this single patient was £73,525 at 1982 prices. In their discussion, the authors concluded that skull fracture is a much better predictor of the likely development of an intracranial haematoma than is a history of unconsciousness and this is especially true in patients who are alert and do not have significant clinical features when seen in A&E.

No policy can hope to lead to the admission of all patients who will develop remediable complications. All policies must balance the risks attributable to each selection criterion. So far in this section it has been shown that although the current policy secures the admission of most patients who develop intracranial haematoma, it encourages delay as well as being enormously expensive. Furthermore, a more selective policy would reduce the number of admissions drastically but at the same time secure the admission of virtually all cases who develop an intracranial haematoma within forty-eight hours. The belief that such a selective policy would lead to a more critical appraisal of patients and reduce delay has not been investigated. Compared to the current

practice and for a hospital admitting one thousand head injuries of all ages each year, the more selective policy would lead to the discharge of one child, who would develop a post-traumatic intracranial haematoma within forty-eight hours, every twenty years. At the same time approximately ten thousand patients would not have been admitted and would have come to no harm as a result, this represents a saving of nearly one million pounds. Also it is by no means certain that the one patient discharged would come to any harm. Moreover, delay in diagnosis and treatment of those admitted would probably be lessened.

On the basis of the foregoing discussion and review of published work, a suggested admission policy is:

ABSOLUTE INDICATIONS

Skull Fracture

Neurological Signs

Early Epilepsy

RELATIVE INDICATIONS

Alcohol

Symptoms

This more selective policy follows from a consideration of work carried out largely in Britain. Jennett (410) has pointed out that such a policy is common practice in the United States, despite the litigious atmosphere prevalent in that country. Indeed even patients known to have a skull fracture may be discharged (217). However, Arnold (415) believes that there is no such thing as a minor head injury and that all patients with a history of unconsciousness, no matter how brief, should be admitted for observation. This latter view is also shared by other American writers (416, 417) but not entirely by others (163, 418, 419, 420).

Those in favour of this more selective admission policy do not deny that these more minor injuries are significant in themselves. Indeed Jones (419) has shown in a large retrospective survey that even among patients not admitted according to the orthodox policy nearly 1% were still symptomatic one year after injury. In a further well designed study, Rimel et al (421) found significant morbidity and unemployment in patients three months

after minor injury. Neuropsychological testing revealed evidence of organic brain damage in the vast majority of the representative sample of sixty-nine patients tested (13% of patients with minor head injury). In this series patients with minor injury were those likely to be discharged if the more selective policy referred to earlier was implemented. In a rather more selected prospective study from New Zealand a fifth of sixty-six adult males who had suffered minor head injury were still symptomatic three months after injury (422). Only five of the total of sixty-six patients had originally been admitted to hospital. At two years only eight of the thirteen patients still symptomatic after three months, could be traced and half of these remained symptomatic, all showing impairment of memory. These authors advocate the admission of minor head injuries so as to allow more thorough neurological examination and explanation to the patient and his relatives of the symptoms of concussion and how to deal with them. Failing this they suggest that such patients, if discharged, should be reviewed two to three days later to allow counselling and in all cases, whether admitted or not, further review should be undertaken after two weeks. The practical implications of this course of action are enormous. The authors offer no evidence that such a policy enhances recovery. Indeed they admit that there is no indication that the organic deficit can be reduced except by natural recovery. Moreover it is difficult to accept that the current 'bed and breakfast' practice common in Britain would confer any benefit or have any remedial effect in concussed patients.

Reporting from Minnesota, Fischer et al (418) discussed hospital observation of seven hundred and thirty-three patients assumed to have minor head injury. They showed that in such patients the presence or absence of skull fracture was of great prognostic value. None of their patients without skull fracture, whether clinically or radiologically determined, developed major neurological sequelae or required neurosurgical intervention. All the morbidity and the only death occurred in patients with skull fracture. By contrast in a smaller study, Karpman et al (420) found neurological complications developed in 3.1% of ninety-six admitted

cases of mild cerebral concussion, none of these had a fractured skull. In fact, none of the seven patients with skull fracture on X-ray developed complications. Two elderly patients deteriorated eight and twelve hours after admission respectively due to subdural haematoma and another was re-admitted five days after discharge when he complained of increasing headache and neck stiffness. In the latter case no intracranial haematoma was present, however traumatic subarachnoid haemorrhage had occurred. An earlier similar study by Plaut and Gifford (417) concerned a hundred and seventy-nine patients with minor head injury admitted to hospital. The state of consciousness immediately following injury was not related to the occurrence or outcome of complications, which occurred in thirteen patients (7.3%). The authors concluded that observation of patients admitted with minor head injuries should last for one week.

It would seem that if the primary aim of admitting head-injured patients to hospital is to permit early diagnosis and treatment of subsequent complications, specifically intracranial haematoma, then a more selective policy would be logical on current evidence. Such a policy would reduce admissions and therefore save money as has been shown. However the expectation that such a policy would reduce mortality and morbidity has not so far been proved, although Weston's paper (51) suggests that such a policy is certainly no worse from this point of view. Introducing such a policy is only part of the answer. Patients discharged must be clearly aware of what symptoms and signs require their immediate re-attendance at the hospital; such information should also always be imparted to a responsible relative able to observe the patient at home. Implicit in this policy is a resolution of the problem of which head-injured patients require skull X-ray. Thus clear guidelines must be formulated setting out the indications for skull X-ray. An essential adjunct is that patients requiring transfer to the regional neurosurgical unit should be identified and a safe and proper method of achieving this transfer without harm to the patient should be agreed.

Head Injury Attendances 1976 - 1977

3.1 MATERIAL AND METHODS:

The Accident and Emergency Department (AED) at Chester Royal Infirmary serves the city and its surrounding rural villages, as well as contiguous parts of Clwyd and Ellesmere Port. Apart from the British Steel plant at Shotton in North Wales there is little heavy industry within the catchment area. However, several light industrial plants are situated in Ellesmere Port. Cross-boundary flow of patients is not great since the majority of the catchment population live and work within the catchment area and only a small number work within the area but live outside it.

A retrospective study of all patients attending AED following head injury was carried out for the year ending 30.06.77. For the purposes of the study a head-injured patient was defined as any patient with one or more of the following:

1. A history of a blow to the head with or without a period of unconsciousness or amnesia.
2. External evidence of injury to the head.
3. Any patient issued with "head injury instructions".
4. All patients undergoing skull X-ray examination.

For practical purposes this definition approximates to rubrics N800-804, N850-854, N870-873, N900, N910, N918-921, N925, N929, N950, N951, of the International Classification of Diseases (Ninth Revision) (423). Patients with epistaxis or foreign bodies in the

eye, ear or nose were excluded unless they fulfilled the above criteria, as, with the same proviso, were patients with burns. Patients with facial injuries, including fractures of the lower jaw, were generally included since they usually fulfilled the definition criteria. Patients admitted because of their head injury were those with diagnoses included in rubrics N800-804, N850-854. Patients with head injury due to birth trauma were excluded.

All patients with head injury who were brought in dead (BID) were included, as were all patients dying at the scene, certified there and taken directly to the mortuary. Coroner's post-mortems for deaths occurring within the catchment area were all performed in Chester, whether death was certified at the scene or on arrival at hospital. The same was true of Home Office post-mortems. All post-mortems during the study period and beyond, irrespective of the source of the patient, were checked to ensure no cases of head injury or of complications were missed. Thus all deaths from head injury occurring within the catchment area of the AED were included. Similarly checks of in-patients registers, operation registers and transfers to other hospitals were undertaken so as to ensure the completeness of the data.

During the study period patients with head injury were selected for admission according to the following policy:

ABSOLUTE INDICATIONS

History of unconsciousness
Period of amnesia
Any neurological sign
Skull fracture
Post-traumatic convulsion

RELATIVE INDICATIONS

Symptoms
Alcohol

In practice a time requirement was also operated, thus patients presenting late (more than 12-24 hours after injury) were only admitted if they had neurological signs on presentation, a compound and/or depressed fracture, post-traumatic convulsions or significant

symptoms. Other injuries or conditions separate from their head injury may have necessitated admission in a small proportion of these late presentations.

Data on the presenting sample of patients with head injury was transferred to a computer input sheet designed by the author (Figure 3.1) and subsequently analysed using the facilities of the Mersey Regional Computer Centre. Age last birthday, source of referral, recent alcohol consumption, pre-existing epilepsy and association with cardiovascular precipitating factors were recorded in addition to day, date and time of arrival at the Accident and Emergency Department. Causes were largely classified by place of occurrence although falls, falls from bicycles and non-accidental injury were recorded separately. In the case of road traffic accidents, causes were subdivided into pedestrians, cyclists, motorcycle riders, pillion-passengers, vehicle drivers, front-seat and rear-seat passengers. The wearing of crash helmets and seat-belts was also noted. Unfortunately the record of X-ray usage was underestimated since no allowance was made for paired structures or for more than one fracture occurring in the same limb. Thus a patient having X-rays of both femora and both tibiae would appear as only one X-ray of the lower limb and if all four bones were broken would be recorded as only one fracture. The number of skull and chest X-rays performed was, however, accurate, but bilateral fractures or pulmonary contusions would appear as only one positive finding. Elements of the history and physical examination were also recorded. A positive entry for the neurological examination required at least an assessment of conscious level and pupil reaction and evaluation of the motor system. Thus the single statement "Moves all four limbs" or "PERLA" did not qualify as a CNS examination and such patients were entered as not recorded for this item. In addition some details of treatment administered, length of stay, time to death and reason for admission were also recorded.

In the analysis of mortality use has been made of the Injury Severity Score (34, 35). Scoring of injuries was as determined from the Abbreviated Injury Scale (1980 Revision) (104).

CHESTER ROYAL INFIRMARY - HEAD INJURIES SURVEY

01 Patient's Number Years Months Sex

02 Mechanism Date of Admission Time of Admission Predisposition

03 Fracture X-Ray

04 Treatment

05 Admitted Mortality Reason

Surname

Address

Figure 3.1 Data Input sheet 1976-77

3.2 RESULTS:

3.2.1 Catchment Population:

Chester district had a population of 182,650 during the study period, based on the average of the mid-1976 and mid-1977 populations as published by the Mersey Regional Health Authority (424, 425). The total catchment population of the area served by the Accident and Emergency Department during the study period was 260,000, additional patients coming largely from North Wales. The estimated age and sex distribution of this population is given in Figure 3.2. This distribution is very significantly different from the age distribution of the average of the mid-1976 (68) and mid-1977 (109) populations of England and Wales, (chi-squared = 2228 D.O.F = 15 p much less than 0.0005). Children were over-represented by 9.4% and elderly patients under-represented by 17% in the catchment population compared to their expected numbers. Also despite the very close agreement between the male/female ratios of the catchment population (0.964) and of England and Wales (0.950) this difference is highly significant (chi-squared = 13.10 p less than 0.0005).

3.2.2 Total Accident and Emergency Attendances:

Unfortunately, in common with most other departments, the wealth of data concerning patients attending the Accident and Emergency Department at Chester Royal Infirmary is not readily available for study. To provide a background to the study of head injury patients and allow a perspective, I manually sorted the total new A&E patients into various groups.

Total new attendances at the A&E department for the years 1970 to 1977 are shown below in Table 3.1, as well as the monthly sub-totals. It can be seen that there is a consistent increase in numbers during the summer months such that a third as many patients again attend as do during the winter. The average annual increase in new patient attendances was 1076, although there was a fall

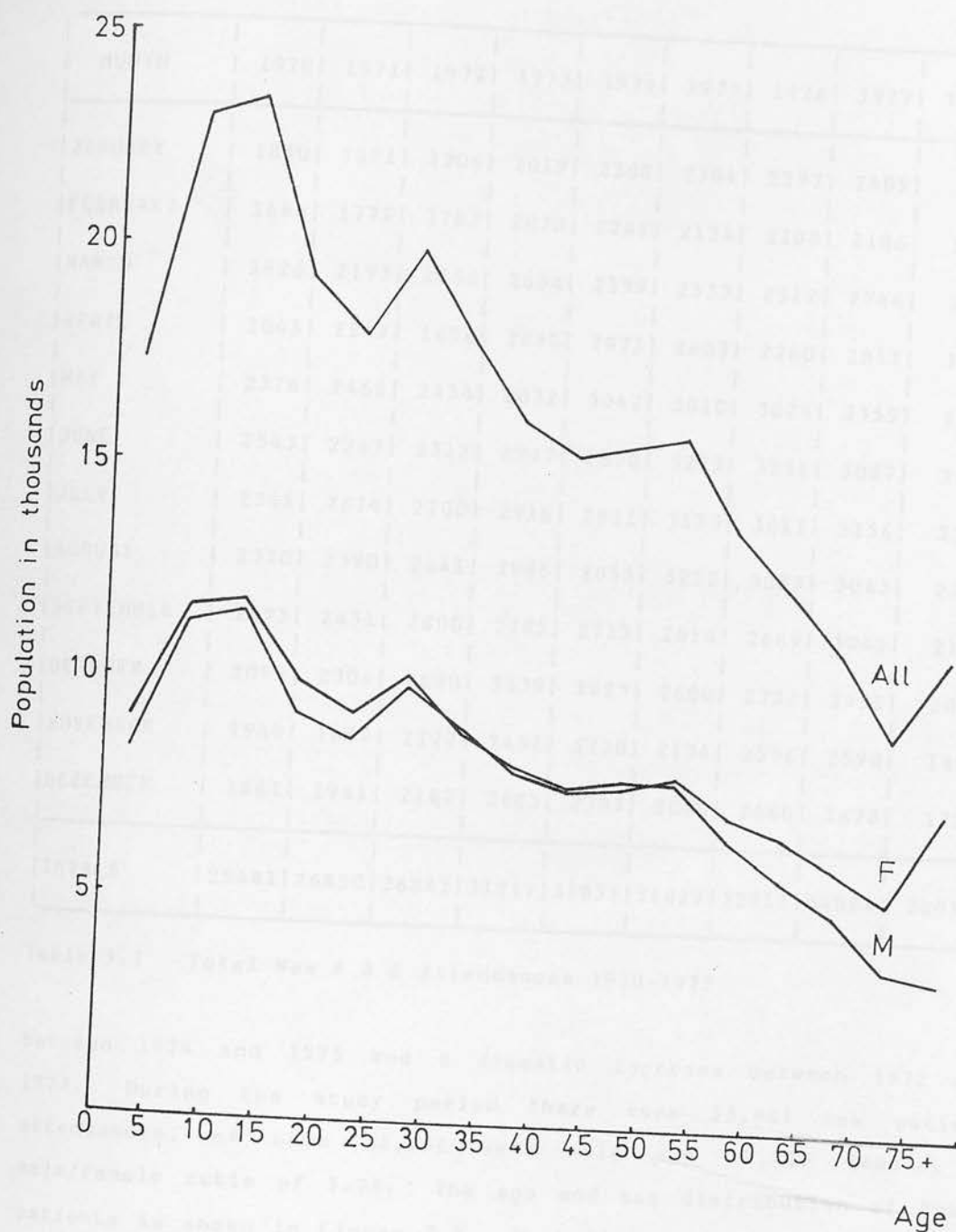


Figure 3.2 Age distribution of catchment population

MONTH	1970	1971	1972	1973	1974	1975	1976	1977	TOTALS
JANUARY	1850	1891	1906	2019	2388	2304	2297	2409	17064
FEBRUARY	1688	1779	1783	2070	2241	2124	2108	2186	15979
MARCH	1826	2193	2256	2654	2599	2533	2512	2746	19319
APRIL	2045	2249	1656	2695	2873	2603	2760	2817	19698
MAY	2376	2468	2434	2872	3047	3010	3026	3355	22588
JUNE	2543	2243	2312	2947	2830	3273	3251	3087	22486
JULY	2345	2674	2700	2916	2931	3153	3411	3156	23286
AUGUST	2370	2390	2441	2908	2853	3212	3033	3043	22250
SEPTEMBER	2493	2451	2600	2785	2723	2814	2669	3042	21577
OCTOBER	2095	2304	2400	2539	2625	2600	2732	2952	20247
NOVEMBER	1949	1867	2172	2451	2338	2134	2556	2590	18057
DECEMBER	1861	1941	2182	2403	2383	2068	2460	2678	17976
TOTALS	25441	26450	26842	31259	31831	31828	32815	34061	240527

Table 3.1 Total New A & E Attendances 1970-1977

between 1974 and 1975 and a dramatic increase between 1972 and 1973. During the study period there were 33,461 new patient attendances, of whom 21,236 were male and 12,225 female, a male/female ratio of 1.74. The age and sex distribution of these patients is shown in Figure 3.3. There is considerable skewness of the distribution to the younger age groups with more than half the patients aged less than twenty-five years and 29% less than fifteen years. Peak attendances in females occurred at age 10-14 years, five years earlier than in males. Further peaks occurred in females at 50-54 years and after seventy-four years. At age sixty-five years the number of females exceeds that of males for the first time and this continues for all subsequent age groups. The overall age distribution is very significantly different from that of the

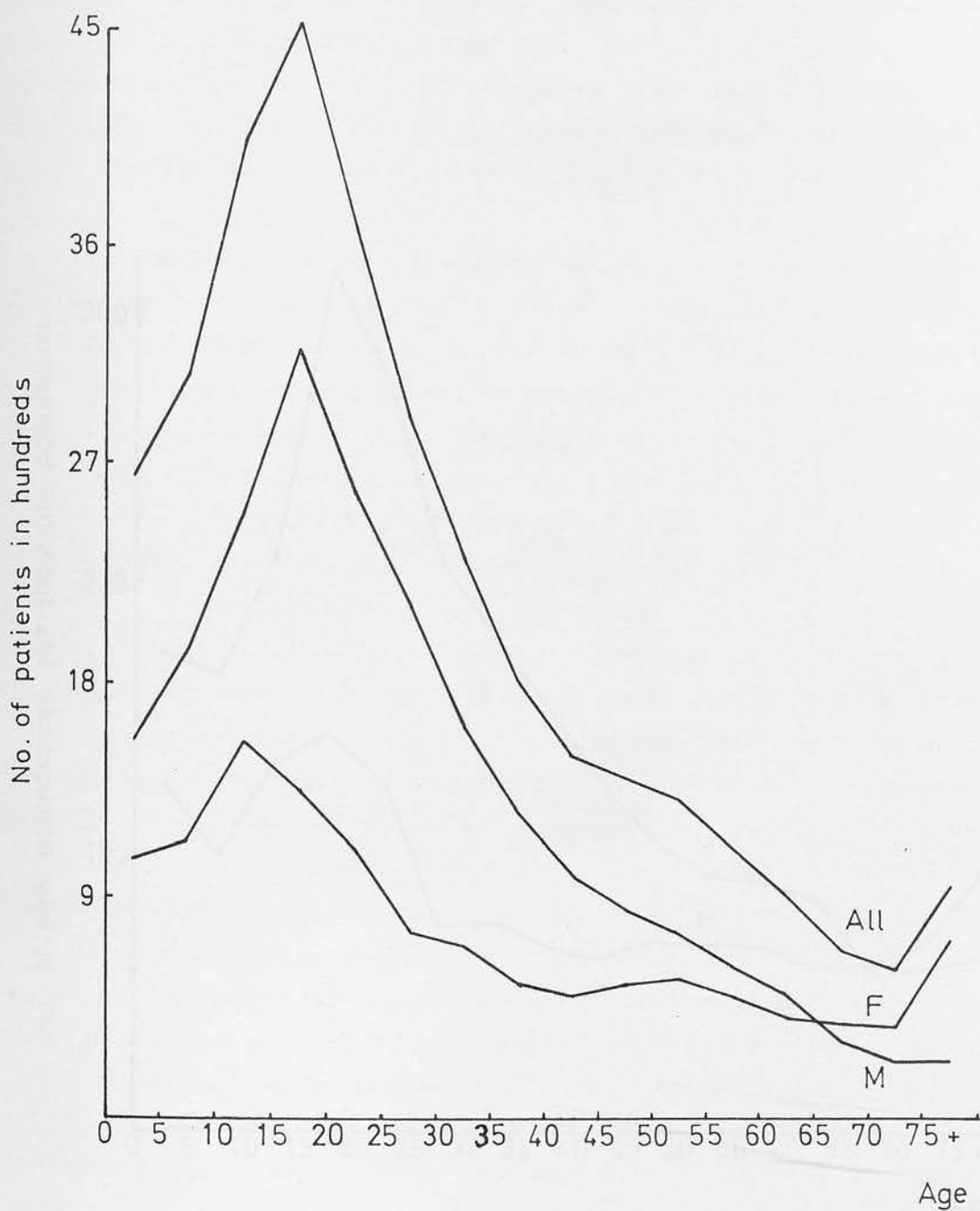


Figure 3.3 Age distribution of all new A&E patients

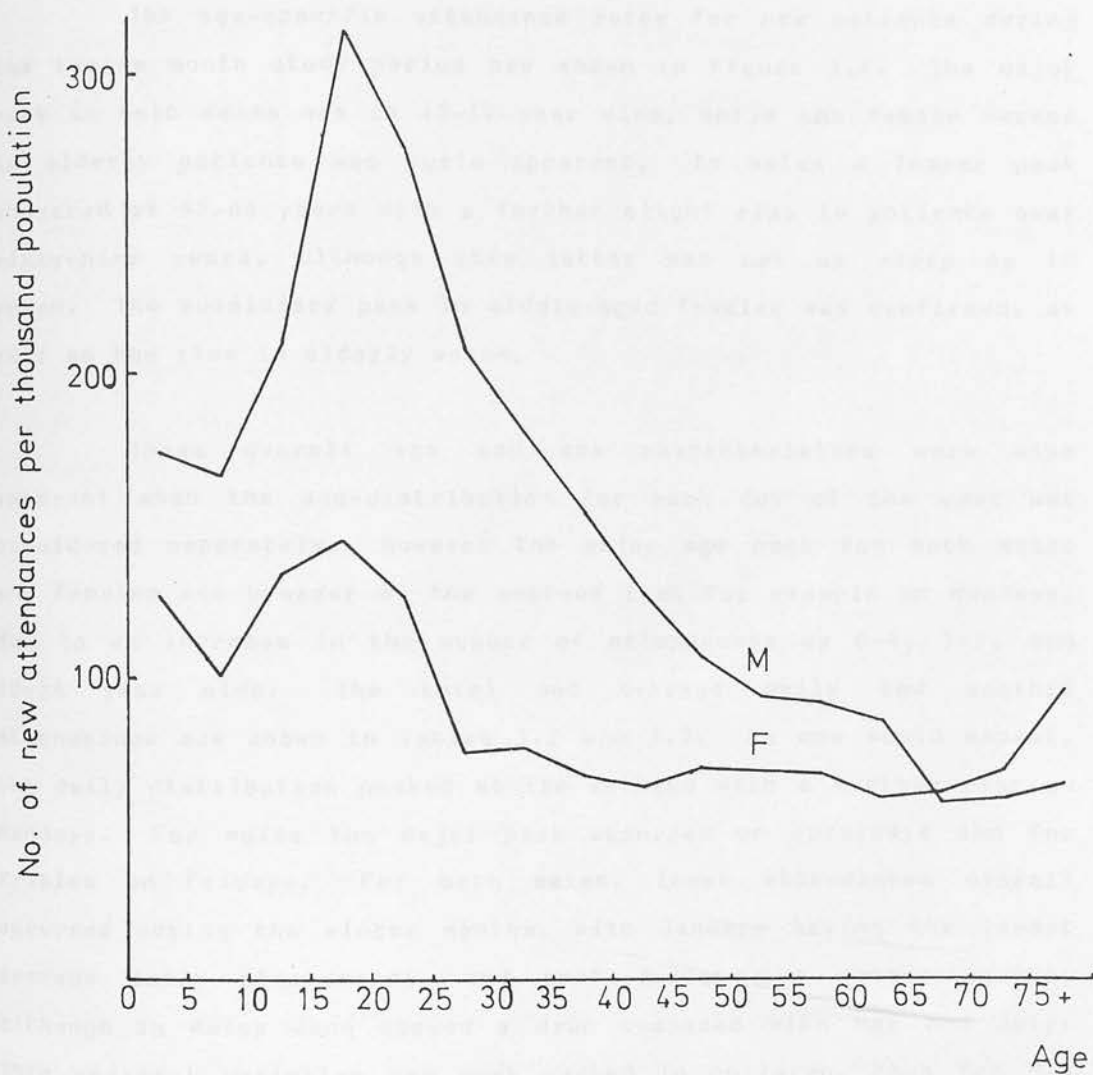


Figure 3.4 Age-specific attendance rates of new A&E patients

catchment population (chi-squared = 4586, D.O.F = 15, p very much less than 0.0005). Patients aged 10-24 years were over-represented by 57% among new A&E patients compared to their expected numbers (by 81% among 15-19 year olds alone), whereas patients over sixty-four years were under-represented by 44%.

The age-specific attendance rates for new patients during the twelve month study period are shown in Figure 3.4. The major peak in both sexes was in 15-19 year olds, while the female excess in elderly patients was again apparent. In males a lesser peak occurred at 55-64 years with a further slight rise in patients over sixty-nine years, although this latter was not as steep as in women. The subsidiary peak in middle-aged females was confirmed, as well as the rise in elderly women.

These overall age and sex characteristics were also apparent when the age-distribution for each day of the week was considered separately. However the major age peak for both males and females was broader at the weekend than for example on Mondays, due to an increase in the number of attendances by 0-4, 5-9, and 20-24 year olds. The total and average daily and monthly attendances are shown in Tables 3.2 and 3.3. As one would expect, the daily distribution peaked at the weekend with a further rise on Mondays. For males the major peak occurred on Saturdays and for females on Fridays. For both sexes, least attendances overall occurred during the winter months, with January having the lowest average daily attendances, and most during the summer months, although in males June showed a drop compared with May and July. This seasonal variation was most marked in children, thus for 0-4 year olds, new attendances were nearly three times as high in the summer as in winter and for all children under fifteen years, a little over twice as many attended in July (1127) as in January (522), whereas for patients aged 15-29 years 1096 attended during July and 839 in January and for patients aged sixty-five years and over the figures were 217 and 171 respectively.

The overall daily distribution is significantly different

DAY	TOTAL	DAILY AVERAGE
MONDAY	4971	95.6
TUESDAY	4678	90.0
WEDNESDAY	4630	89.0
THURSDAY	4799	90.5 *
FRIDAY	4803	92.4
SATURDAY	5001	96.2
SUNDAY	4579	88.1
TOTAL	33461	91.7

*53 Thursdays

MONTH	TOTAL	DAILY AVERAGE
JULY	3411	110.0
AUGUST	3033	97.8
SEPTEMBER	2669	89.0
OCTOBER	2732	88.1
NOVEMBER	2556	85.2
DECEMBER	2460	79.4
JANUARY	2409	77.7
FEBRUARY	2186	78.1
MARCH	2746	88.6
APRIL	2817	93.9
MAY	3355	108.2
JUNE	3087	102.9
TOTAL	33461	91.7

Table 3.2 Total new A&E attendances
by day of week

Table 3.3 Total new A&E
attendances by
month of the year.

from one in which equal numbers of patients are assumed to attend on each day of the week (chi-squared = 33.5, D.O.F = 6, p less than 0.0005). Using the "zI test" (426) attendances on Mondays and Saturdays were significantly higher and on Wednesdays and Sundays significantly lower than expected, if equal numbers of patients were assumed to have attended on each day of the year. Again using the "zI test" (426) the number of attendances by new patients in May, June, July and August was significantly greater (z more than 3.5, p less than 0.002) and those in October, November, December, January and February significantly lower (z more than 2.0, p less than 0.05)

than expected if equal numbers of patients were assumed to attend on each day of the year. New attendances for the remaining months were not significantly different from their expected values.

The hourly distribution of new patients is shown in Figure 3.5. Three major peaks were evident, each succeeding peak being lower than its predecessor. Thus the highest peak occurred in the late morning (11.00-12.00 hours) with further peaks in the early afternoon (14.00-15.00 hours) and early evening (17.00-18.00 hours) and a further small peak in the late evening (23.00-24.00 hours). 41% of all patients attended between 09.00 and 17.00 hours on Mondays to Fridays and 42% between 17.00 and 09.00 hours throughout the week (33% between 17.00 and 24.00 hours).

Considering the hourly distribution for each day separately certain patterns emerged. For weekdays the highest peak still occurred in the morning, but was earlier, either 09.00-10.00 hours or 10.00-11.00 hours. The afternoon peak was consistent at 14.00-15.00 hours, while the early evening peak occurred at 17.00-18.00 hours or 18.00-19.00 hours. No late night peak occurred except on Fridays, when it was at 23.00-24.00 hours. On Saturdays and Sundays the morning peak was at 11.00-12.00 hours and the number of attendances between 08.00 and 11.00 hours was much lower than during the week. The afternoon peak occurred later at 15.00-16.00 hours and was higher and more sustained than the corresponding peak during the week, extending into the early evening so that the early evening peak disappeared and a late evening peak was present at 23.00-24.00 hours.

When the hourly distribution of patients for each month was considered separately, seasonal variations became noticeable. The highest daily peak tended to occur earlier during the summer months (10.00-11.00 hours) than during the winter (11.00-12.00 hours) while the early afternoon peak was unchanged. The early evening peak occurred later in the winter and spring (18.00-19.00 hours) and earlier during the remainder of the year (17.00-18.00 hours). In addition there was a small late night peak in September, October

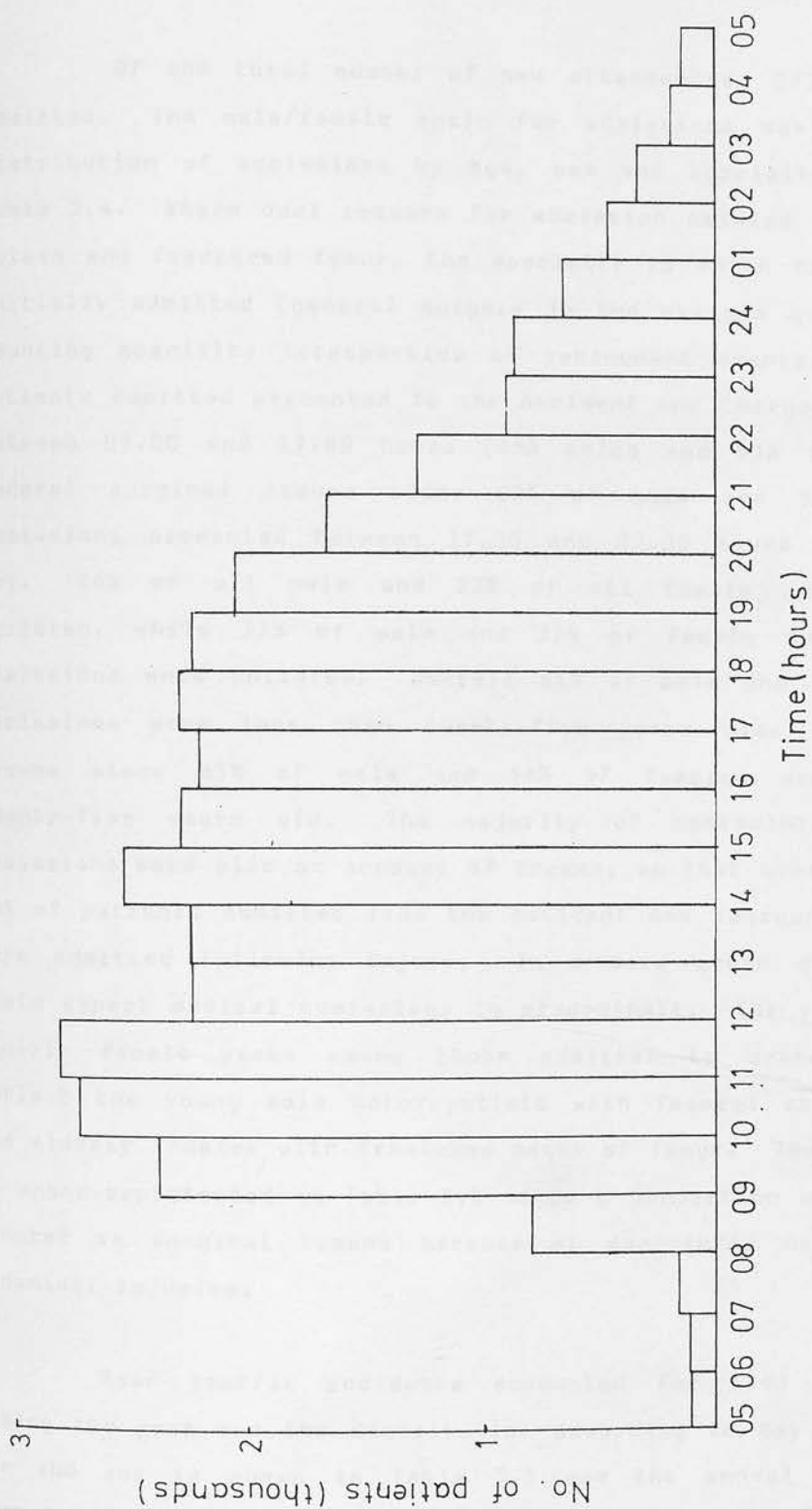


Fig 3.5 Hourly distribution of all new A & E patients

and November only, occurring at 23.00-24.00 hours. During the summer and autumn the early evening peak was slightly higher than the early afternoon peak, otherwise the stepwise fall in numbers with each succeeding peak was maintained.

Of the total number of new attendances, 2774 (8.3%) were admitted. The male/female ratio for admissions was 1.54 and the distribution of admissions by age, sex and specialty is shown in Table 3.4. Where dual reasons for admission existed e.g., ruptured spleen and fractured femur, the specialty to which the patient was initially admitted (general surgery in the example quoted) was the counting specialty irrespective of subsequent events. 48% of all patients admitted presented to the Accident and Emergency Department between 09.00 and 17.00 hours (45% males and 53% females). For general surgical trauma alone 62% of male and 55% of female admissions presented between 17.00 and 09.00 hours the following day. 26% of all male and 23% of all female admissions were children, while 33% of male and 32% of female surgical trauma admissions were children. Overall 51% of male and 39% of female admissions were less than twenty-five years old. For surgical trauma alone 65% of male and 54% of females were less than twenty-five years old. The majority of ophthalmic and dental admissions were also on account of trauma, so that overall more than 60% of patients admitted from the Accident and Emergency Department were admitted following injury. In a more urban department one would expect medical admissions to predominate. The young male and elderly female peaks among those admitted to orthopaedic wards reflect the young male motorcyclists with femoral shaft fractures and elderly females with fractured necks of femur. The former group is under-represented in Table 3.4 since a proportion will have been counted as surgical trauma because of associated head, chest or abdominal injuries.

Road traffic accidents accounted for 1743 new patients during the year and the distribution according to day of the week, age and sex is shown in Table 3.5 and the annual figures from 1969-1977 are shown below in Table 3.6. For females, Thursday was

SPECIALTY	AGE		0-9		10-19		20-29		30-39		40-49		50-59		60-69		70-79		80+		TOTAL	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
GENERAL SURGERY	20	17	27	30	36	27	21	13	14	7	16	5	21	2	9	7	2	171	110			
	164	94	234	64	150	43	58	34	42	21	47	21	37	24	23	29	6	15	761	355		
ORTHOPAEDIC TRAUMA	39	13	75	11	48	10	34	7	15	8	27	23	20	29	17	64	8	73	283	238		
GENERAL ORTHOPAEDICS	8	3	2	3	2	2	2	0	2	1	4	1	1	2	0	1	0	0	21	13		
PAEDIATRICS	71	64	4	3														75	67			
MEDICINE			10	20	28	33	20	20	53	12	54	31	68	16	17	10	0	3	250	145		
GERIATRICS													13	10	20	33	10	34	43	77		
PSYCHIATRY	0	0	4	2	9	4	6	3	2	2	2	0	1	0	2	0	2	0	28	11		
ENT	3	2	2	3	3	2	1	2	0	1	2	6	4	8	0	7	0	1	15	32		
EYES	7	4	11	2	4	3	4	1	3	2	1	2	1	5	0	2	2	1	33	22		
GYNACOLOGY				6		4		4		4				1					0	17		
FACIO-MAXILLARY	1		1	1		1								1					0	4		
OBSTETRICS						1													0	3		
TOTAL	312	197	369	145	280	130	146	86	131	56	153	89	166	98	88	153	35	129	1680	1094		

Table 3.4 Admissions from the A&E department by age, sex and specialty 1976-1977.

DAY	AGE		0-9		10-19		20-29		30-39		40-49		50-59		60-69		70-79		80+		TOTAL	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
MONDAY	12	5	54	8	43	19	19	11	16	5	14	6	4	1	2	4	1	1	1	165	57	
TUESDAY	14	9	55	16	31	13	19	6	7	6	14	5	4	2	8	7	0	2	152	66		
WEDNESDAY	10	3	64	15	49	16	26	13	10	11	12	6	7	7	2	8	1	0	181	79		
THURSDAY	18	9	67	17	47	20	21	13	19	11	7	5	11	10	3	5	0	0	193	90		
FRIDAY	15	6	76	14	44	19	17	14	12	7	15	8	15	4	4	4	0	1	198	77		
SATURDAY	12	4	71	16	41	17	10	5	12	10	11	4	5	6	8	7	0	1	170	70		
SUNDAY	11	8	66	23	45	22	15	11	11	4	10	8	4	2	1	2	1	1	164	81		
TOTAL	92	44	453	109	300	123	127	73	87	54	83	42	50	32	28	37	3	6	1223	520		

Table 3.5 All road accidents by age, sex and day of week 1976-1977.

the commonest day of attendance and for males Friday. 55% of all

YEAR	1969	1970	1971	1972	1973	1974	1975	1976	1977
TOTAL	1915	1924	2012	1930	1927	1685	1663	1759	1676

Table 3.6 Annual totals for RTA's 1969 - 1977

patients were under twenty-five years old (60% males and 44% females) and 58% attended between 17.00 and 09.00 hours the next day. July was the busiest month for road traffic accidents with October and November close behind. For patients aged 10-14 years most accidents occurred at weekends. 27% of all accidents and 32% of male accidents occurred in 15-19 year olds from 17.00 hours on Fridays until 09.00 hours on Mondays. Around midnight was the commonest time for accidents to occur. Overall peaks were evident at 09.00-10.00, 13.00-14.00, 17.00-18.00, and 23.00-24.00 hours corresponding with travel to work, lunch-breaks, returning home and pub closure.

3.2.3 Head Injured Patients: All Accident & Emergency Attendances:

i. Incidence, Age and Sex:

5768 patients satisfied the requirements for inclusion as head injuries, representing 17.2% of new A&E attendances. The incidence was therefore 2218/100,000, 3088/100,000 for males and 1379/100,000 for females. 44% of patients were under fifteen years old and only 6% were over sixty-four years (3.4% males and 11.6% females). The overall male/female ratio was 2.16 varying from 3.74 in those aged 25-29 years to less than 1 in those over sixty-four years of age and less than 2 in those aged 0-4 years and 45-64 years.

The age and sex distribution of these patients is shown in Figure 3.6. In both sexes the major peak occurred in the younger age groups, 0-4 years in girls and 5-9 years in boys. In males a further substantial peak occurred at age 15-19 years, with minor peaks at 35-39 and 55-59 years. The female distribution showed a rapid decline from its highest value in 0-4 year olds with a minor rise in 15-24 year olds, until age 25-29 years after which it remained more or less constant, and from sixty-five years onwards the number of females exceeded the number of males. The age-specific distribution was essentially the same, as can be seen in Figure 3.7. However the bias due to the excess of elderly females in the population was removed so that only in patients aged 70-74 years did the female age-specific rate exceed that of males. Also in both sexes the rate rose again in elderly patients.

The age-distribution of all attenders with head injury is significantly different from that of all new A&E patients (chi-squared = 1296, D.O.F = 15, p very much less than 0.0005). Most of the difference is due to a marked over-representation of children aged 0-9 years in the head-injured group together with a moderate under-representation of all other age groups except for patients over seventy-four years old who were represented in proportion. Over-representation of children in the head-injured group was 99%. The age-distribution of all attenders with head

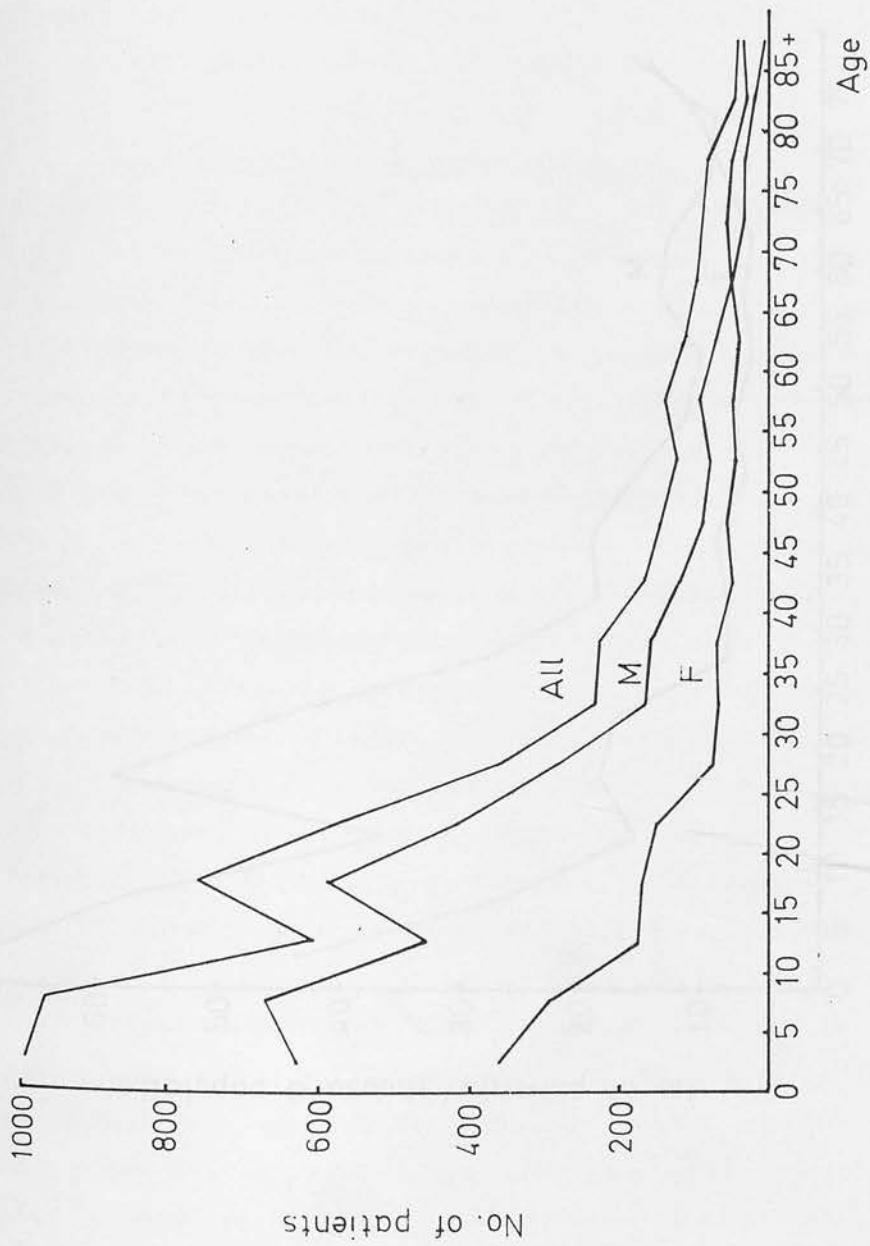


Figure 3.6 Age distribution of all Head Injuries 1976 -1977

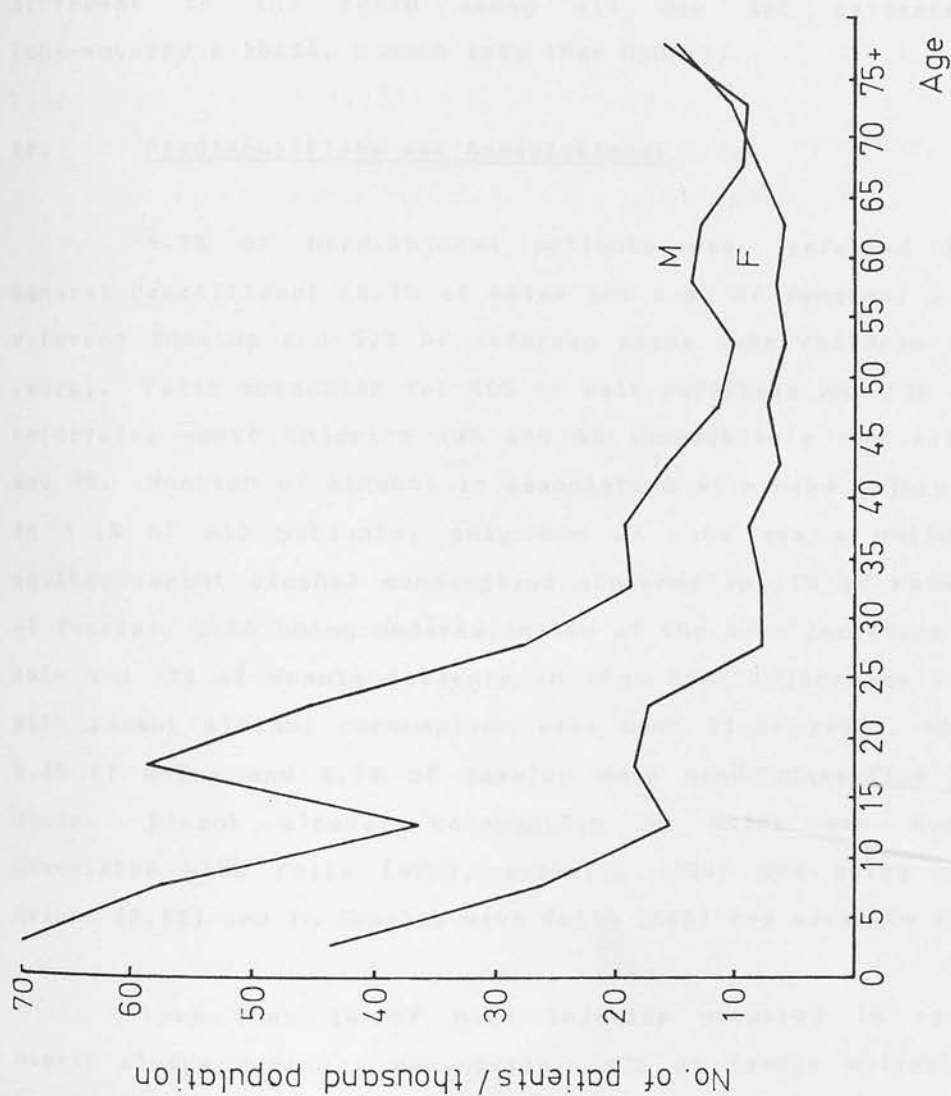


Figure 3.7 Age-specific attendance rates of Head Injuries 1976-1977

injury was also significantly different to the age-distribution of the catchment population (chi-squared = 2578, D.O.F = 15, p very much less than 0.0005) due to over-representation of patients aged 0-24 years in the head-injured group and an under-representation of all other ages. Over-representation in patients aged 0-4 years was 158%, fell to 18% in patients aged 10-14 years and rose to 77% in 15-19 year olds before falling again. As well as the significant differences in regard to age-distribution the overall sex ratio for all A&E attenders with head injury (2.16) was significantly different to the ratio among all new A&E patients (1.74) (chi-squared = 50.34, p much less than 0.0005).

ii. Predispositions and Associations:

5.3% of head-injured patients were referred by their General Practitioner (4.7% of males and 6.6% of females) and 46% of referred females and 52% of referred males were children (under 15 years). Falls accounted for 40% of male referrals and 53% of female referrals, sport injuries 13% and 8% respectively and assaults 8% and 3%. Mention of alcohol in association with head injury occurred in 5.1% of all patients, only one of whom was a child. Among adults, recent alcohol consumption occurred in 11% of males and 6% of females, both being underestimates of the true incidence. 39% of male and 32% of female patients in whom head injury was associated with recent alcohol consumption were aged 15-24 years, while only 8.1% of males and 8.3% of females were aged sixty-five years or older. Recent alcohol consumption in males was most often associated with falls (42%), assaults (30%) and being a vehicle driver (8.5%) and in females with falls (60%) and assaults (23%).

Less than 1% of head injuries occurred in epileptics, nearly always during a convulsion. 42% of female epileptics with head injury were aged 20-24 years, while 40% of males were aged 35-39 years and in both sexes other age-groups each contributed either a very small proportion or none to the total, 17% were children, mostly girls. 91% of epileptics were injured in falls, 6% at work and only one patient in other circumstances - a twelve year

old boy who was knocked off his bicycle.

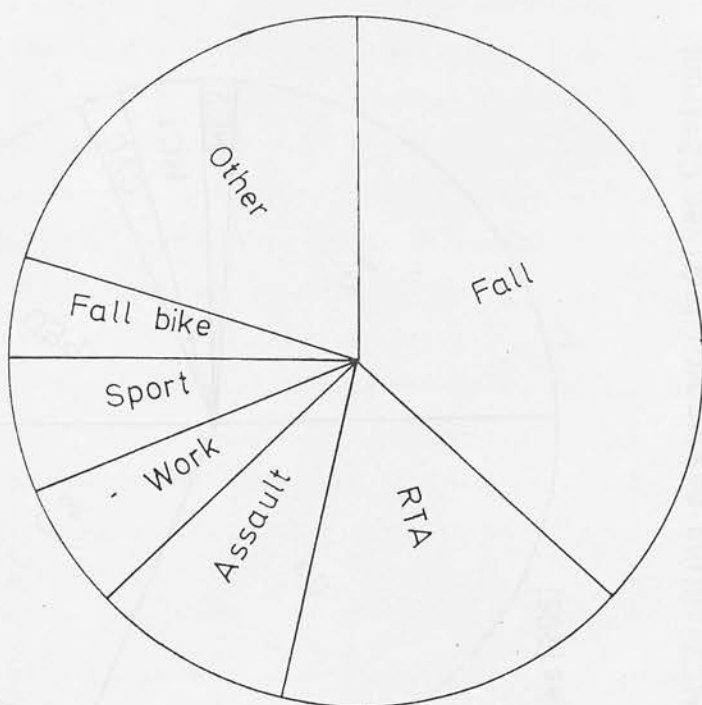
Overall 1.5% had cardiovascular predispositions, being more than twice as common in females (2.6%) as in males (1%). Such associations were particularly common in older patients, more than a third being over sixty-four years. In both sexes cardiovascular predispositions were largely associated with falls (89% males and 98% females), however in 7.5% of males their cardiovascular predisposition led to their being injured when driving.

Altogether nineteen patients were attended at the scene of their injury by the Flying Squad. Only one of these was not injured in a road traffic accident. One third were aged 15-19 years and 58% were aged 15-29 years. A third were car drivers and a fifth were pedestrians. Fifteen patients were male and four were female.

iii. Causes:

Figure 3.8 shows the proportion of head injuries which can be attributed to each cause in all cases and in both males and females. The ranking of the first three causes was the same in both although quantitative differences occurred. Thus falls were relatively more common in females and assaults less common, with road traffic accidents being about the same. Ranking of causes thereafter followed a predictable pattern in keeping with current social differences, industrial accidents ranking fourth in males followed by sport, then falls from bicycles and finally non-accidental injuries, whereas in females, falls from bicycles was the fourth commonest followed by sport injuries, industrial injuries and lastly non-accidental injury. Industrial injury was nearly six times as common and sports injuries twice as common in males as in females, while falls from bicycles and non-accidental injury were equally common in both.

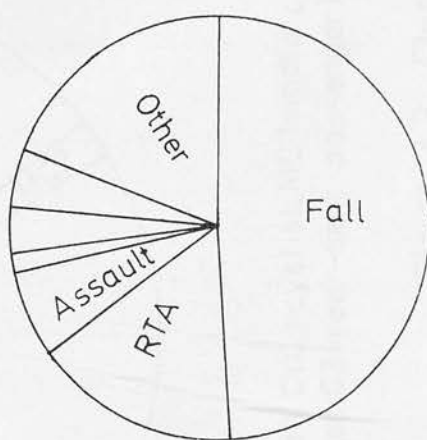
When road traffic accidents were further classified then sex differences become noticeable (Figure 3.9). Motor-cycle injuries were almost exclusively male (89%), of whom only one in



All patients (5768)

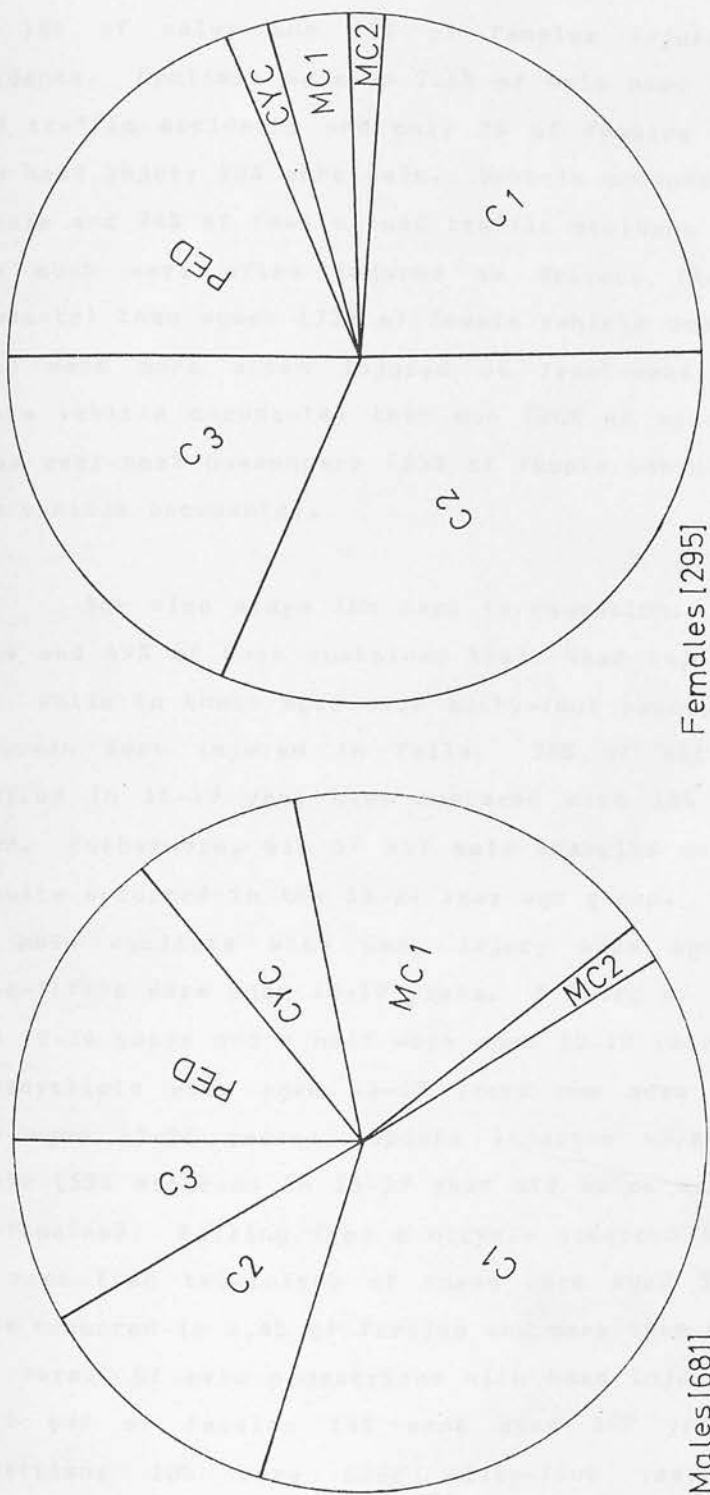


Males (3941)



Females (1827)

Figure 3.8 Causes of Head Injuries 1976-1977



(PED =pedestrian, CYC =cyclist, MC1=motorcycle rider, MC2=pillion-passenger, C1=driver, C2=front -seat passenger, C3=rear-seat passenger)

Figure 3.9 Classification of RTAs

eleven were pillion-passengers compared with one in three women motorcyclists injured as pillion-passengers. Pedestrians accounted for 14% of males and 19% of females injured in road traffic accidents. Cyclists made-up 7.6% of male head injuries incurred in road traffic accidents and only 2% of females and of all cyclists with head injury 90% were male. Vehicle occupants accounted for 59% of male and 74% of female road traffic accident victims, however men were much more often injured as drivers (66% of male vehicle occupants) than women (32% of female vehicle occupants). Conversely women were more often injured as front-seat passengers (43% of female vehicle occupants) than men (20% of male vehicle occupants) or as rear-seat passengers (25% of female vehicle occupants, 14% of male vehicle occupants).

Age also plays its part in causation. In children, 56% of girls and 49% of boys sustained their head injury as a result of a fall, while in those aged over sixty-four years, 64% of men and 78% of women were injured in falls. 38% of all assaults in males occurred in 15-19 year olds compared with 18% of all assaults in women. Furthermore, 61% of all male assaults and 42% of all female assaults occurred in the 15-24 year age group. Nearly two-fifths of all male cyclists with head injury were aged 10-14 years and three-fifths were aged 10-19 years. A third of female cyclists were aged 10-14 years and a half were aged 10-19 years. 60% of all male motorcyclists were aged 15-19 years and more than three-quarters were aged 15-24 years. Sports injuries were commoner in young people (59% occurred in 15-29 year old males and 44% in 15-29 year old females). Falling from a bicycle occurred in 4.9% of all males and more than two-thirds of these were aged 5-14 years. Such a cause occurred in 4.4% of females and more than two-thirds were aged 5-9 years. Of male pedestrians with head injury 43% were aged 2-9 years and of females 24% were aged 2-9 years while for male pedestrians 10% were over sixty-four years and for female pedestrians 25% were over sixty-four years. Nearly a fifth of male vehicle drivers were aged 20-24 years compared with a quarter of women drivers. These variations with age and sex are summarised in Table 3.7. The wearing of seat belts or crash helmets was

appropriate in 654 patients, however, only 29% definitely took such a precaution.

CAUSE	ALL AGES		0 - 14YEARS		15 - 64YEARS		65 + YEARS	
	n=5768		n=2573		n=2845		n=350	
	M%	F%	M%	F%	M%	F%	M%	F%
ASSAULT	11	6.5	1.1	0.6	20	15	0	0
INDUSTRIAL	8.0	1.4	0	0	15	3.3	2.2	0
SPORT	7.6	3.8	4.0	3.6	11	5.1	1.5	0
FALL	31	49	49	56	14	33	64	78
FALL BIKE	4.9	4.4	8.4	9.2	2.0	0.5	3.6	0
PEDESTRIAN	2.5	3.0	3.3	2.6	1.4	2.4	7.3	6.6
CYCLIST	1.3	0.3	1.6	0.2	1.0	0.4	3.6	0.5
MOTORCYCLIST	3.0	0.6	0	0	5.7	1.4	0.7	0
PILLION	0.3	0.3	0	0	0.6	0.6	0	0
CAR DRIVERS	6.7	3.8	0	0	12	8.3	12	1.9
F. PASSENGER	2.0	5.1	0.4	0.4	3.4	9.9	2.2	6.6
R. PASSENGER	1.4	3.0	1.2	2.8	1.7	3.8	0.7	0.9
OTHER	20	19	31	25	12	16	2.9	5.2
TOTAL [100%]	3941	1827	1733	840	2071	774	137	213

Table 3.7 Causes of head injury by age group and sex: All A&E attenders 1976-1977

iv. Temporal Relationships:

The hourly distribution of patients is shown in Figure 3.10, for both males and females. In males two peaks occurred, the first and highest in the early evening (17.00-19.00 hours) and the other between 23.00 and 24.00 hours. In females the situation is less clear cut, however, a late afternoon-early evening peak

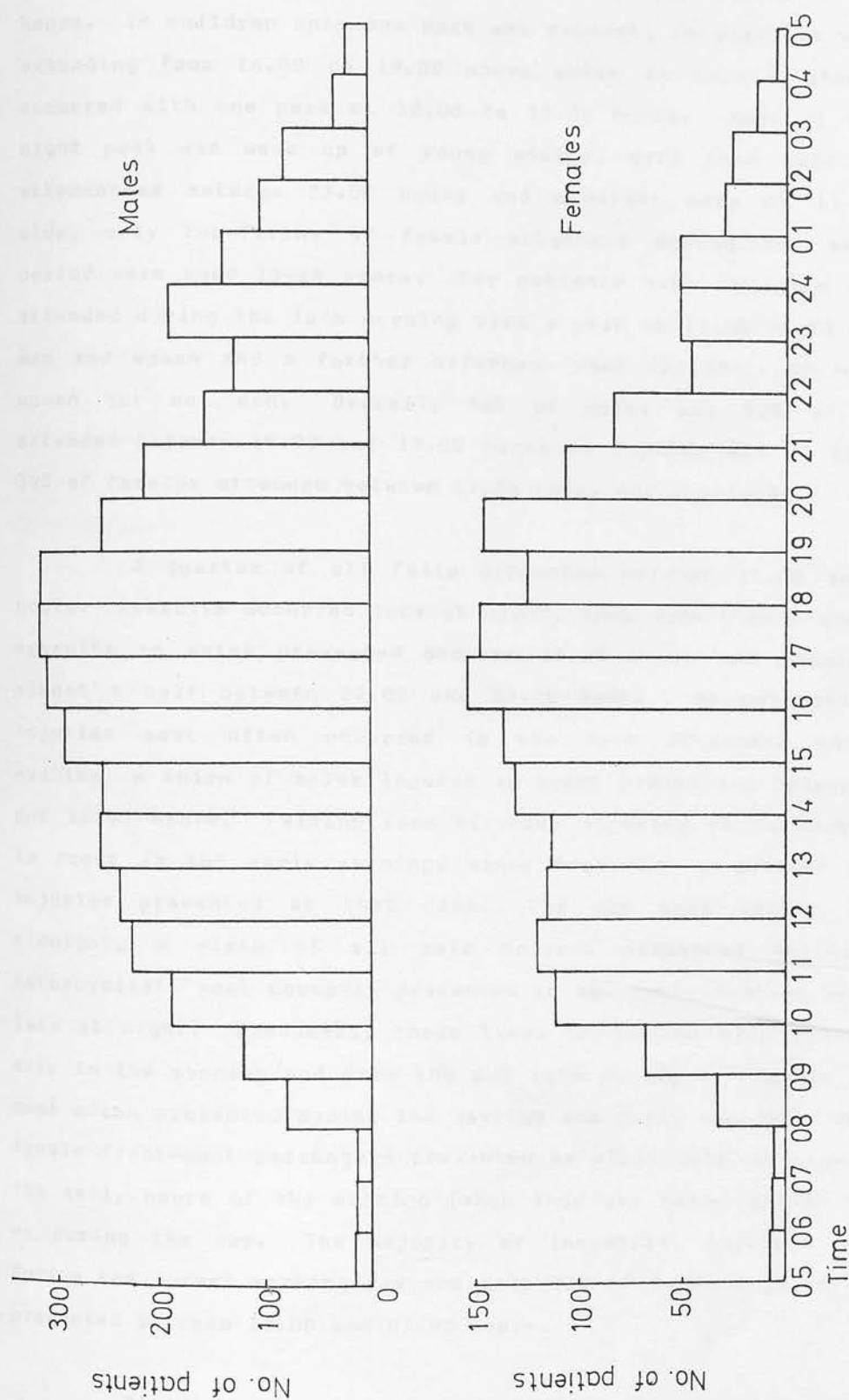


Figure 3.10 Hourly distribution of Head Injuries 1976-1977

occurred at 16.00-17.00 hours with a further slight rise at 19.00-20.00 hours. The late night peak was less apparent than in males and was both broader and flatter extending from 23.00 to 01.00 hours. In children only one peak was evident, in girls it was broad extending from 16.00 to 19.00 hours while in boys a steady rise occurred with one peak at 18.00 to 19.00 hours. Most of the late night peak was made up of young adults, more than half of male attendances between 23.00 hours and midnight were by 15-24 year olds, only two-fifths of female attenders during the same time period were aged 15-24 years. For patients over 64 years old most attended during the late morning with a peak at 11.00-12.00 hours in men and women and a further afternoon peak (14.00-15.00 hours) in women but not men. Overall, 48% of males and 52% of females attended between 09.00 and 17.00 hours, a further 40% of males and 39% of females attended between 17.00 hours and midnight.

A quarter of all falls presented between 16.00 and 19.00 hours. Assaults occurred late at night, thus more than a quarter of assaults in males presented between 23.00 hours and midnight and almost a half between 23.00 and 03.00 hours. By contrast, sport injuries most often occurred in the late afternoon and early evening, a third of males injured in sport presenting between 15.00 and 18.00 hours. Falling from bicycles appeared to be most likely to occur in the early evening, since more than a quarter of such injuries presented at that time. For one hour either side of midnight, a sixth of all male drivers presented whereas male motorcyclists most commonly presented in the early evening and again late at night. Presumably these times correspond with return from work in the evening and from the pub late at night. Female drivers most often presented during the daytime and early evening. However, female front-seat passengers presented as often late at night or in the early hours of the morning (when they are being driven by men) as during the day. The majority of industrial injuries occurred during the normal working day and only 26% of males injured at work presented between 17.00 and 09.00 hours.

Dividing the hourly distribution of all attenders with head

injury into equal periods of three hours (07.00-09.59, 10.00-12.59 etc.) and comparing this to the distribution of all new A&E patients showed a significant difference (chi-squared = 349.25, D.O.F = 7, p less than 0.0005). Head injury attenders were under-represented during the daytime and over-represented in the evening and at night, compared to their expected values.

The daily and monthly distributions for both sexes are shown in Figures 3.11 and 3.12. The average number of daily attendances for all patients was 15.8, for Saturdays it was 17.1 and for Sundays 16.6. For males, Saturday was the commonest day for head injury to occur and for females most occurred mid-week. For boys, Mondays, Thursdays and Sundays were the commonest days and for girls Wednesdays. 18% of young male adults aged 15-24 years presented on Saturdays, whereas 16% of similarly aged women presented on Thursdays.

Once again a seasonal trend was apparent with more attendances for head injury during the summer. The fall in male attendances in June is not explained. It affected mainly young age groups, particularly 15-19 year olds. A possible relationship to O and A level examinations might explain this but would not account for the relatively high numbers in May or the lack of a similar fall in young women. The seasonal trend was most readily seen in young children. In January, 74 boys aged 0-9 years attended the Accident and Emergency Department and in July in the same age group there were 134 attendances. For girls of the same age the figures were 29 and 78 respectively. For the same two months, attendances by 10-19 year olds totalled 69 and 105 for males and 20 and 38 for females. During the months of June, July and August, attendances by boys under ten years were 80% higher than for the December to February quarter, and for girls were doubled.

November was the busiest month for assaults in males and October in females. Industrial accidents were fairly evenly distributed throughout the year, except for a low number in June and a high in January. The majority of sports injuries in males

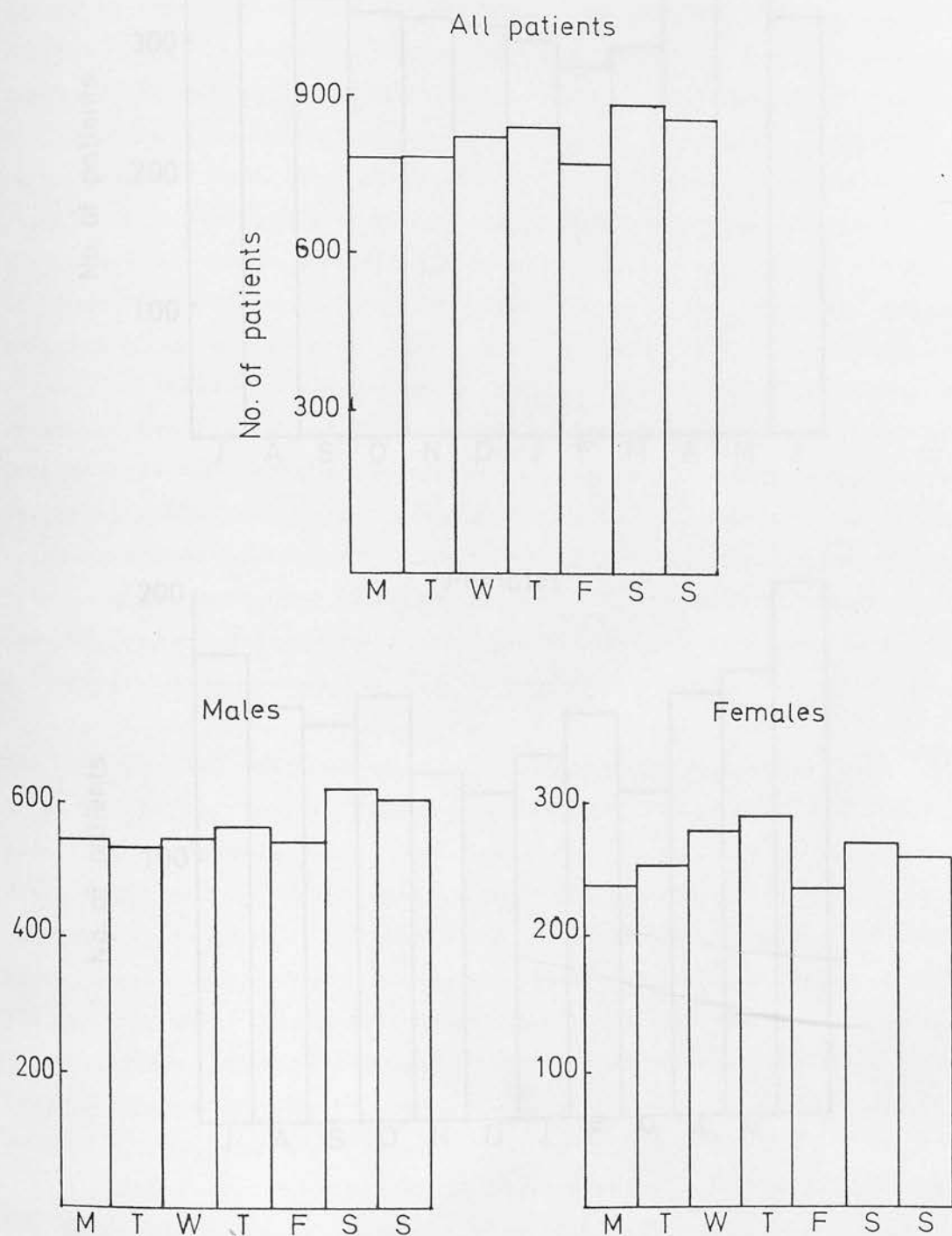


Figure 3.11 Daily distribution of Head Injuries 1976-1977

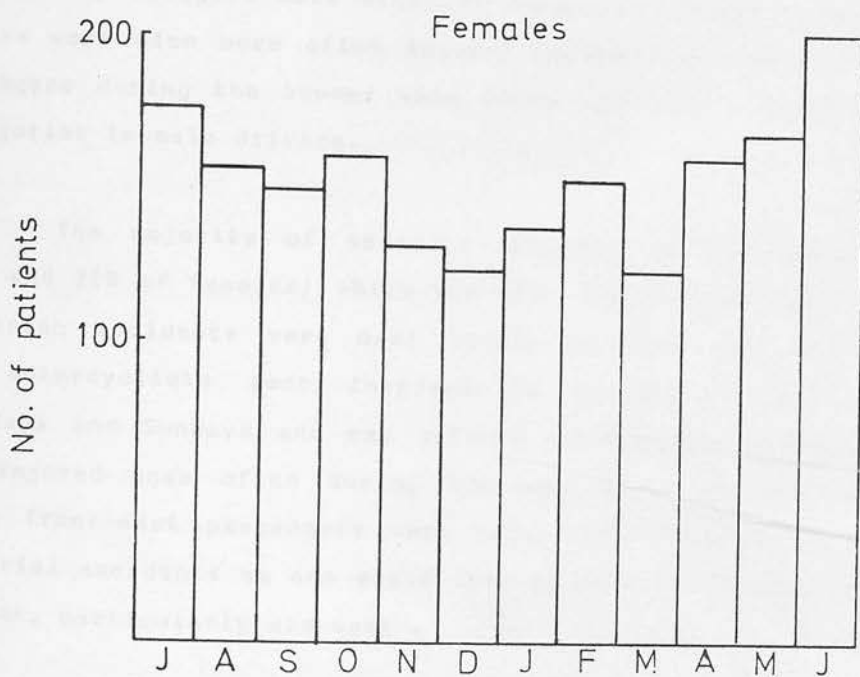
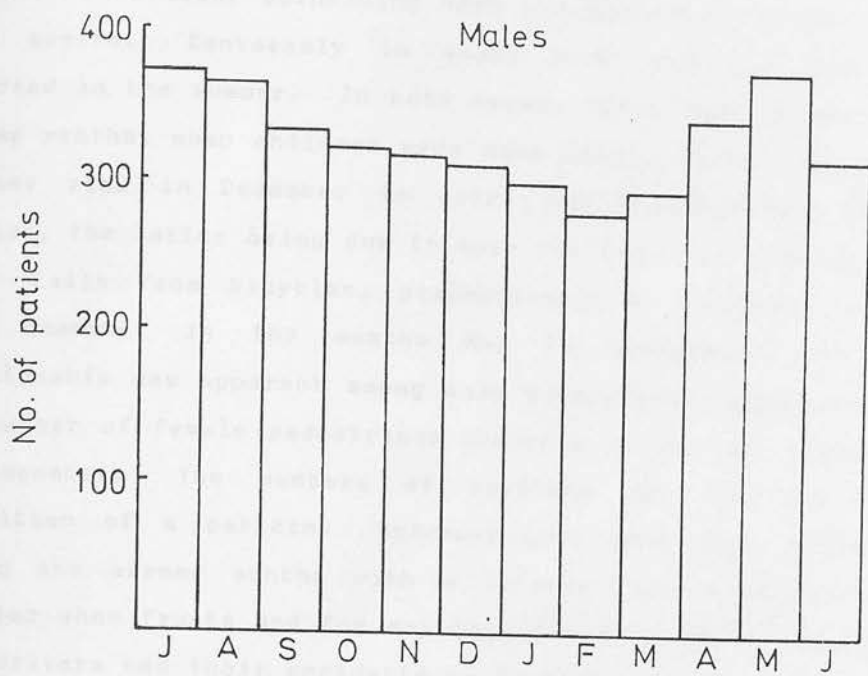


Figure 3.12 Monthly distribution of Head Injuries 1976-1977

occurred in October coinciding with the beginning of the season for many sports. Conversely in women such injuries more commonly occurred in the summer. In both sexes, falls were commonest in the summer months, when children were most likely to be injured, with a further rise in December in males and December and January in females, the latter being due to more falls in the elderly of either sex. Falls from bicycles, predominantly a childhood occurrence, were commoner in the months May to September. No clearcut relationship was apparent among male pedestrians, however a rise in the number of female pedestrians occurred during the period October to December. The numbers of cyclists was too few to allow definition of a pattern. Motorcyclists were most often injured during the warmer months with a further rise during October and November when frosts and fog may have played a part. Nearly 30% of male drivers had their accidents in November and December, whereas a fifth of male rear-seat passengers were injured in July and front-seat passengers more often in autumn and early winter. Women drivers were also more often injured during the winter, front-seat passengers during the summer when there was also a slight increase in injuries to male drivers.

The majority of assaults occurred on Saturdays (22% of males and 21% of females) which was also the busiest day for falls. Pedestrian accidents were most likely on Thursdays and Fridays. Male motorcyclists were involved in accidents more often on Saturdays and Sundays and car drivers on Fridays. Female drivers were injured more often during the week than at weekends, while female front-seat passengers were more often injured at weekends. Industrial accidents as one would expect, most often occurred during the week, particularly mid-week .

The daily distribution is significantly different from both the daily distribution among all new A&E patients (chi-squared = 16.82, D.O.F = 6, p less than 0.01) and a distribution which assumes equal numbers of head-injured patients attend on each day (chi-squared = 13.92, D.O.F = 6, p less than 0.05) this difference is due to an under-representation of head injury attenders during

the early part of the week especially Mondays and an over-representation at the weekend, especially Sundays. Contrary to the trend for increasing representation from Monday to Sunday head injury attendances on Fridays were under-represented. Using the "zI test" (425) head injury attendances on Saturdays were significantly higher ($z = 2.33$, p less than 0.05) than would be expected if equal numbers of patients were assumed to attend on each day of the year. Total attendances on each of the remaining days were not significantly different to their expected values.

Comparison of the monthly distribution among all head injury attenders with that among all new A&E patients just fails to show a significant difference (chi-squared = 19.38, D.O.F = 11, p less than 0.1 more than 0.05). Again using the "zI test", the numbers of head injury attenders in May, June and July were significantly greater (z more than 2.0, p less than 0.05) and those in December, January and March were significantly lower (z more than 2.4, p less than 0.05) than expected if equal numbers of patients were assumed to attend on each day of the year. Head injury attendances during the remaining months were not significantly different from their expected values.

v. History Symptoms and Signs:

A history of unconsciousness was present in 15% of all patients, yet in a further 19% the presence or absence of this feature was not recorded. In the case of patients involved in road traffic accidents only 5.1% of patients had this factor unrecorded. Assuming those patients with no record of the presence or absence of unconsciousness were not knocked out at the time of injury, then a history of unconsciousness was less common in children (8.7%) than in adults (21%) and was least common in 0-4 year olds (4.9%). A history of unconsciousness became more common as age increased. With the same proviso, males were most likely to be rendered unconscious if they were involved in road traffic accidents and least likely to be knocked out if injured at work. Thus 67% of pillion-passengers, 51% of pedestrians and motor-cycle riders, 37%

of cyclists and 30% of car drivers had such a history, compared with only 10% of those injured in industrial accidents. Falls (12%), sport injuries (12%), assaults (14%) and falling from bicycles (22%) generally had proportions at the lower end of the range. Road traffic accidents were also the cause most likely to be associated with a history of being knocked out in females - 60% of pillion-passengers, 36% of motor-cycle riders, 31% of pedestrians, 30% of front-seat passengers, 29% of drivers and 26% of rear-seat passengers. Falling off a bicycle was least likely to produce initial unconsciousness in females, only 12% being knocked out. Assaults (14%), falls (15%), sport (21%) and industrial injuries (23%) were intermediate. Of all episodes of unconsciousness in females, 46% were due to falls and 31% due to road traffic accidents, and in males 24% of all episodes of unconsciousness were due to falls and 41% due to road traffic accidents. For patients with a skull fracture on X-ray, 64% (68% male and 58% female) had been knocked out, 26% had not, and in 10% this feature was unrecorded.

Amnesia of any duration occurred in 7.5% of males and 6.8% of females. Conversely this finding was definitely absent in 4.6% of both males and females. In the remaining 88% of males and 89% of females its presence or absence was not noted by the doctor. Only one child under five years was recorded as having amnesia and seven were recorded as not having amnesia. For obvious reasons all eight were older children. In general the same relationship between amnesia and cause occurred as between unconsciousness and cause. In males 49% of all episodes of amnesia resulted from road traffic accidents and 18% from falls; in females the figures were 37% and 40% respectively. A fifth of patients with skull fracture on plain X-ray had a period of amnesia (24% of males and 13% of females) while in more than three-quarters the presence or absence of amnesia was unrecorded.

Vomiting occurred in 7.4% overall and was slightly more common in females (8.4%) than males (6.9%). Vomiting did not occur in 58% of both sexes. In children, vomiting was more common than in

adults, occurring in 10% and again was commoner in girls. This symptom was twice as common among patients injured in falls as in patients involved in road traffic accidents. A fifth of patients with a fracture on plain skull films experienced vomiting, once again this was commoner in females.

Neurological signs of any type, predominantly alterations in the conscious level, occurred in 4.9% of all patients, in 4.6% of males and 5.7% of females. These findings were commoner in children than adults, occurring in 6.5% of 0-4 year olds and 5.1% of all children compared with 4.8% of all adults. Disturbingly, however, in 37% of all patients there was either no or an inadequate record of a central nervous system examination i.e., the minimum requirement of an assessment of conscious level and pupil reaction and motor function was not met. Signs were more than twice as common in the victims of road traffic accidents as in other patients, being present in 8.9% and 3.9% respectively. Signs were particularly common in all cyclists (17%) and all pedestrians (13%) and in male pedestrians (13%), male cyclists (15%) and male motorcyclists (13%). Of all patients with neurological signs 46% had been injured in falls (55% females and 42% males) and 31% had been injured in road traffic accidents (34% males and 24% females). 42% of all patients with skull fracture on plain X-ray had neurological signs and this was more common in males (44%) than in females (39%).

vi. Plain X-Rays:

Overall 2881 patients (50%) had plain skull films and of these, eighty-nine patients (3.1%) had fractures or diastasis confirmed by the radiologist. If patients not having a skull X-ray are assumed to have no skull fracture then 1.5% of all patients had a radiologically apparent skull fracture. Clinically diagnosed fractures with negative skull X-ray would add to this figure, as would fractures occurring in BIDs. Fractures on skull films were more common in patients with a history of unconsciousness, thus 65% of patients with fractures had been unconscious. Other features

which were more common in patients with skull fracture on X-ray were amnesia of any duration, which was present in a fifth, vomiting also present in a fifth and neurological signs, present in 42%. Conversely only 6.5% of all patients with a history of unconsciousness had a skull fracture on X-ray and this characteristic alone correctly identified two-thirds of skull fractures. Similarly 14% of patients with neurological signs had a skull fracture and this finding alone identified 42% of skull fractures. 46% of all radiologically apparent fractures occurred in children and 1.6% of all children, whether X-rayed or not had skull fracture compared with 1.5% of all adults. Road traffic accidents accounted for 17% of all head injuries and 36% of all skull fractures seen on plain X-ray.

Query fractures on skull X-ray (i.e., diagnosed as fractures or ? fractures by the accident unit staff but reported as no bony injury by the radiologist) occurred in thirty-seven patients and in three additional patients a ? fracture was confirmed as a definite fracture by the radiologist. These forty patients represented 1.4% of all those having skull X-ray and 0.7% of all patients. Thus for every two patients correctly diagnosed as having a fracture on X-ray, a further patient was diagnosed as having a fracture when no fracture was present. No attempt was made to assess the acceptability of skull films for diagnostic purposes.

Not all patients with fractures were admitted, nor did all patients with fracture who were admitted have the fracture diagnosed prior to admission. Thirteen cases of missed fracture were found, representing nearly 1 in 7 fractures, five of these were admitted, three as query fractures and two as no bony injury. The remaining eight patients were discharged, one with a small, closed depressed fracture and the others with linear fractures. In six cases, including the depressed fracture, the skull films were considered entirely normal by the Accident and Emergency Department staff, in the remaining patients the fracture was incorrectly identified as a prominent vascular marking or a fracture involving the ipsilateral orbit. A correct radiological diagnosis was made in 85% of cases of

skull fracture, in 3.4% a fracture was suspected, in 2.2% a fracture was misdiagnosed and in 9% completely missed. None of the patients with skull fracture who were discharged came to any harm, although one later presented to the ENT department with anosmia.

Assuming patients in whom the facts were unrecorded were negative for that fact then skull fracture on X-ray was significantly correlated with initial unconsciousness (chi-squared = 165.6, p much less than 0.0005), a period of amnesia (chi-squared = 19.9, p less than 0.0005), vomiting (chi-squared approximately = 19.9, p less than 0.0005) and neurological signs (chi-squared = 263.7, p much less than 0.0005).

Altogether 63% of all patients had at least one part X-rayed. The proportion of patients having each site X-rayed and the proportion of those X-rayed who had positive findings are shown in Table 3.8. For the reasons already given, the number of upper and

PART X-RAYED	PERCENTAGE OF PATIENTS HAVING PART X-RAYED	PERCENTAGE OF X-RAYED PATIENTS WITH POSITIVE FINDINGS
SKULL	50	3.1
FACE	9.6	9.9
NOSE	6.8	57
MANDIBLE	1.9	32
CERVICAL SPINE	3.6	2.4
UPPER LIMB	7.1	45
CHEST	6.1	14
THORACIC SPINE	0.7	21
LUMBAR SPINE	1.1	14
PELVIS	2.1	25
LOWER LIMB	5.1	34
ABDOMEN	0.6	2.8
ANY	63	19

Table 3.8 Proportion of patients X-rayed according to anatomical site

lower limb X-rays were underestimated, particularly the former group. The low proportion of patients with cervical spine injury is noteworthy, representing only 0.09% of all head-injured patients if patients not X-rayed are assumed to have no fracture or dislocation. 5% of all patients had a fracture and/or dislocation of the limbs. If a high proportion of positive findings correlates with clinical ease of diagnosis then cervical spine, abdominal injuries and head injuries are most difficult to diagnose clinically. X-rays of the nasal bones have the highest proportion of positive findings, followed by limb injuries. Two thirds of patients X-rayed had only one site X-rayed, 786 (22%) had two separate sites X-rayed, 266 (7.3%) had three separate sites X-rayed, 110 (3%) had X-rays of four separate sites, 26 (0.7%) of five sites, 12 (0.3%) of six sites and 1 of seven sites. A total of 5470 sites were X-rayed and a positive result was obtained at 789 sites (14.4%). Fifty-six patients had positive results at two separate sites, sixteen at three separate sites and two at four separate sites. Bilateral limb fractures and two or more fractures in the same limb were not unusual, nor were bilateral chest injuries, however bilateral skull or facial bone fractures were uncommon. Fractures and/or dislocations of the spine occurred in twenty-three patients only - five cervical, nine thoracic and nine lumbar.

Of patients knocked out, 20% had at least one fracture excluding the skull, and this was commoner in males (21%) than females (16%). Similarly, patients with amnesia or neurological signs were twice as likely to have fractures outside the skull as patients without these characteristics e.g., 26% of males with neurological signs had fractures outside the skull compared with 10% of males without neurological signs.

3.2.4 Admitted patients:

i. Incidence Age and Sex:

Eleven hundred and seven patients were admitted, eight of these were initially discharged, but admitted, usually because of symptoms, when they returned to the Accident and Emergency Department later. Six more patients were re-admitted after discharge from the general surgical wards. 4661 patients were not admitted, sixty-six of these took their own discharge and a further twenty-three returned to the department because of symptoms and were again discharged. A further twenty-three patients were dead on arrival at hospital.

Of the admitted patients, seven hundred and ninety-three (72%) were admitted because of a head injury alone, one hundred and seventy-nine (16%) were admitted because of another injury or condition alone and one hundred and thirty five (12%) because of a head injury plus another injury or condition. Thus there were nine hundred and twenty-eight head injury admissions, representing 2.8% of all new accident and emergency patients during the study period and 16% of all A&E attendances with head injury. The admission rate was therefore 357/100,000, 498/100,000 for males and 221/100,000 for females.

For head injury admissions the male/female ratio was 2.17, no different to that among all A&E attenders. However the ratio rose from 1.27 in patients aged 0-4 years to 4.56 in patients aged 10-14 years and thereafter declined, falling below 2.0 in patients over twenty-nine years old before rising to 2.4 in 40-44 year olds. In patients over sixty-four years the ratio was 0.68.

The age-distribution is shown for all head injury admissions and for both males and females in Figure 3.13. A third of all admitted patients were under fifteen years of age and 8.5% were over sixty-four years old. Above age sixty-four years the number of females exceeded that of males for the first time and

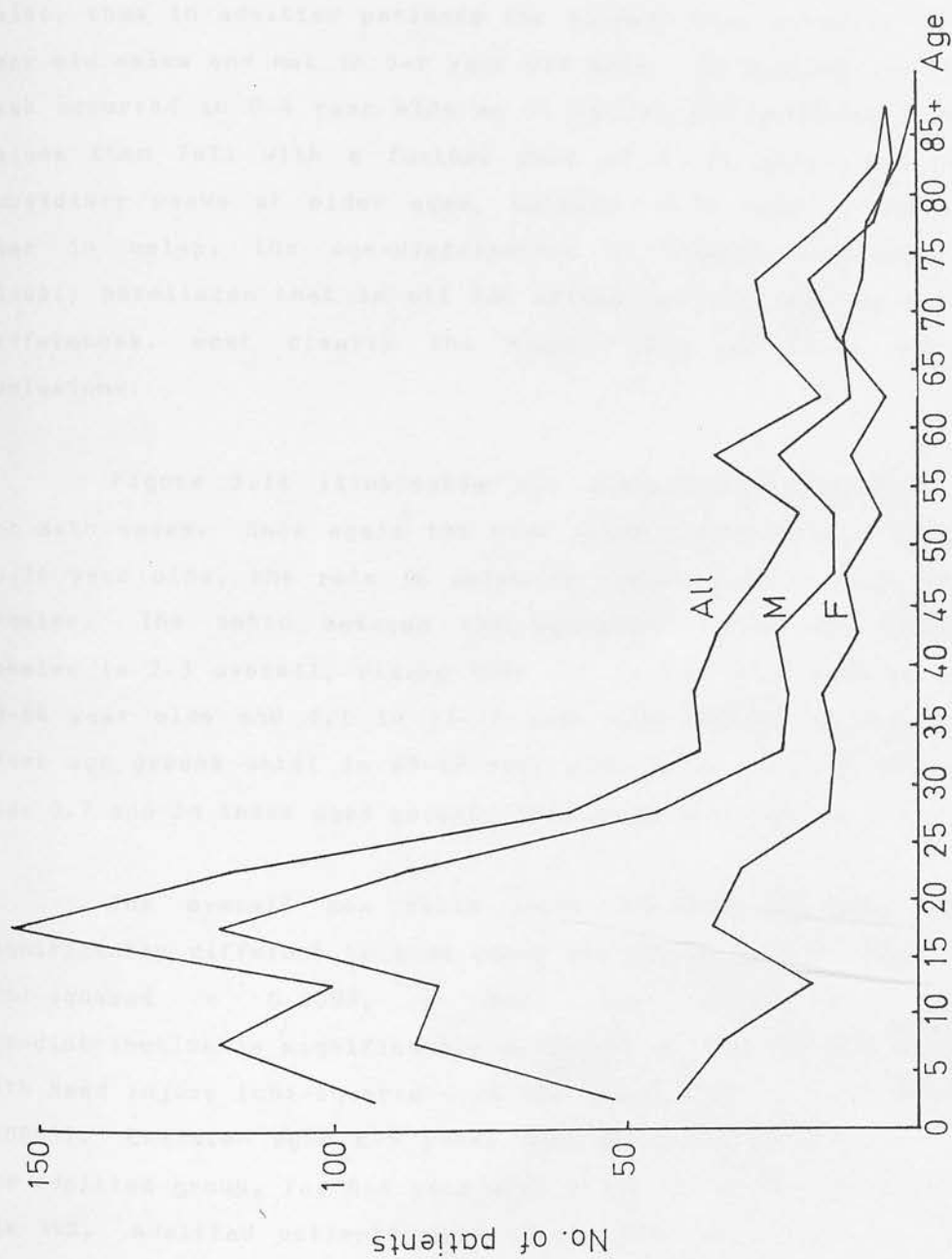


Figure 3.13 Age-distribution of admitted Head Injuries 1976-1977

apart from 75-79 year olds, the female excess persisted. The age-distribution in males showed four peaks at 5-9, 15-19, 40-44 and 55-59 years with the peak at 15-19 years being the highest. The position of these three peaks agrees with that found for all attenders (Figure 3.6) except that the 40-44 year peak occurs five years earlier among all attenders. Quantitative differences also exist, thus in admitted patients the highest peak occurred in 15-19 year old males and not in 5-9 year old boys. In females the highest peak occurred in 0-4 year olds as it did in all attenders, and the values then fell with a further peak at 15-24 years and several subsidiary peaks at older ages, notably 70-74 years. Unlike the case in males, the age-distribution of female admissions more closely paralleled that in all A&E attenders with some quantitative differences, most clearly the higher peak in 15-24 year old admissions.

Figure 3.14 illustrates the age-specific admission rates for both sexes. Once again the same peaks are evident. Except in 70-74 year olds, the rate in males is always greater than that in females. The ratio between the admission rates for males and females is 2.3 overall, rising from 1.2 in 0-4 year olds to 4.4 in 10-14 year olds and 3.1 in 15-19 year olds before falling in the older age groups until in 65-69 year olds it is 1.1, in 70-74 year olds 0.7 and in those aged seventy-five years and over 1.6.

The overall sex ratio among admitted patients is not significantly different to that among all attenders with head injury (chi-squared = 0.0003, p more than 0.95) however the age-distribution is significantly different to that of all attenders with head injury (chi-squared = 64.68, D.O.F = 15, p much less than 0.0005). Children aged 0-9 years were under-represented by 29% in the admitted group, for 0-4 year olds alone the under-representation was 38%. Admitted patients aged 15-19 years were over-represented by 22% and patients aged 20-24 years by 19% compared to their expected numbers. All other age groups were represented in proportion or differed little from their expected numbers except for 60-69 year olds who were over-represented by 59%.

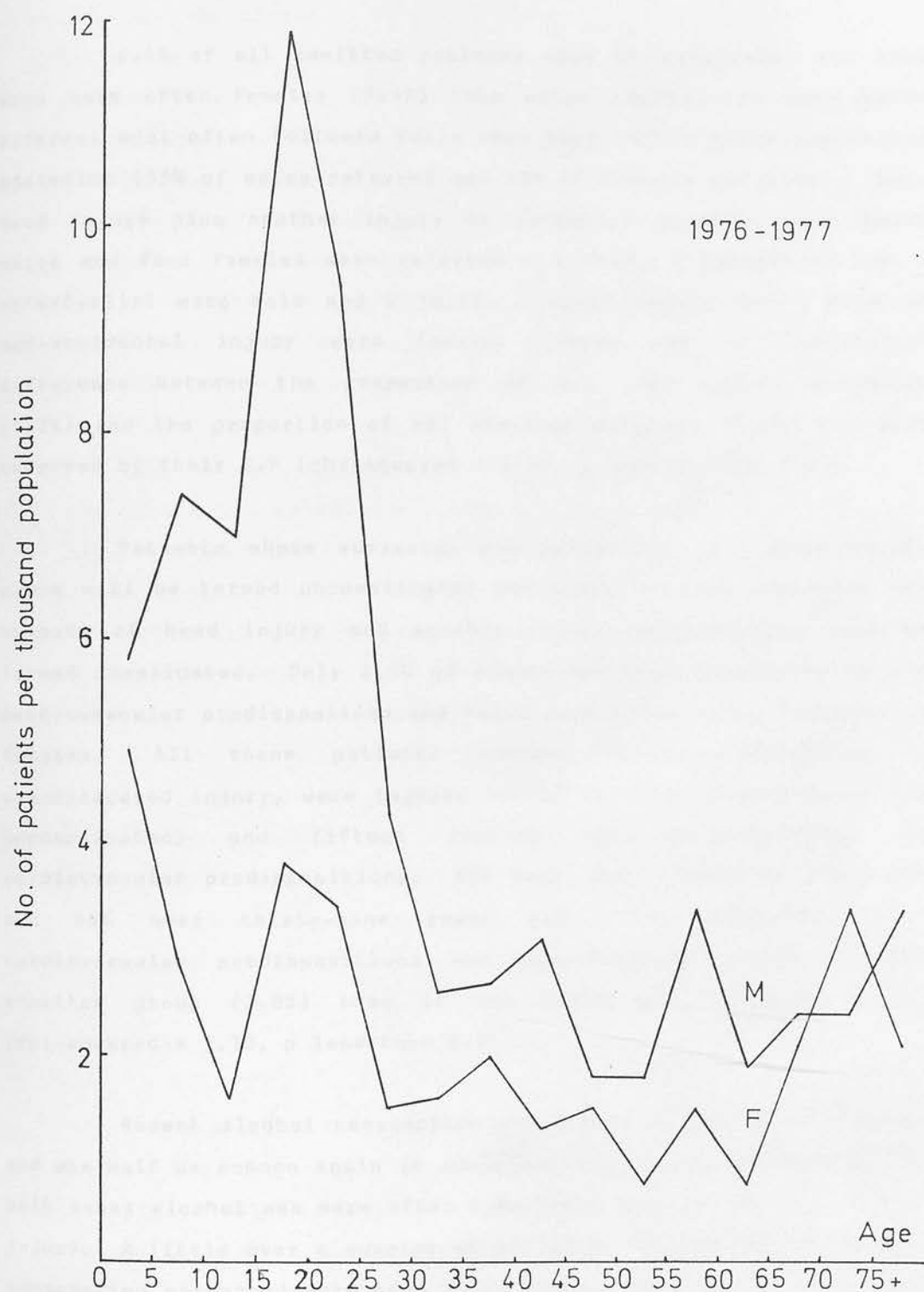


Figure 3.14 Age-specific admission rates for Head Injury

ii. Predispositions and Associations:

6.4% of all admitted patients were GP referrals, and they were more often females (7.9%) than males (5.7%). In both sexes referral most often followed falls when head injury alone determined admission (55% of males referred and 58% of females referred). When head injury plus another injury or condition existed, only three males and four females were referred - 1 fall, 1 pedestrian and 1 motorcyclist were male and 2 falls, 1 sport injury and 1 case of non-accidental injury were female. There was no significant difference between the proportion of all head injury attenders (5.3%) and the proportion of all admitted patients (6.4%) who were referred by their G.P (chi-squared = 1.46, p greater than 0.2).

Patients whose admission was determined by a head injury alone will be termed uncomplicated and those in whom admission was because of head injury and another injury or condition will be termed complicated. Only 2.8% of admissions were associated with a cardiovascular predisposition and these were three times commoner in females. All these patients whether having complicated or uncomplicated injury, were injured in falls. Thus eleven males (10 uncomplicated) and fifteen females (11 uncomplicated) had cardiovascular predispositions. 42% were over sixty-four years old and 69% over thirty-nine years old. The proportion with cardiovascular predispositions was significantly higher in the admitted group (2.8%) than it was among all attenders (1.5%) (chi-squared = 7.30, p less than 0.01).

Recent alcohol consumption was noted in 16% of all adults and was half as common again in adult males as in adult females. In both sexes alcohol was more often associated with uncomplicated head injury. A little over a quarter of all males in whom recent alcohol consumption was noted were aged 20-24 years. Alcohol was most often associated with injuries sustained in falls, assaults and road traffic accidents in both sexes. Among males with uncomplicated head injury, sixty-four (12%) had recent alcohol consumption noted and of these 28% were involved in assaults, 39% in falls and 25% in

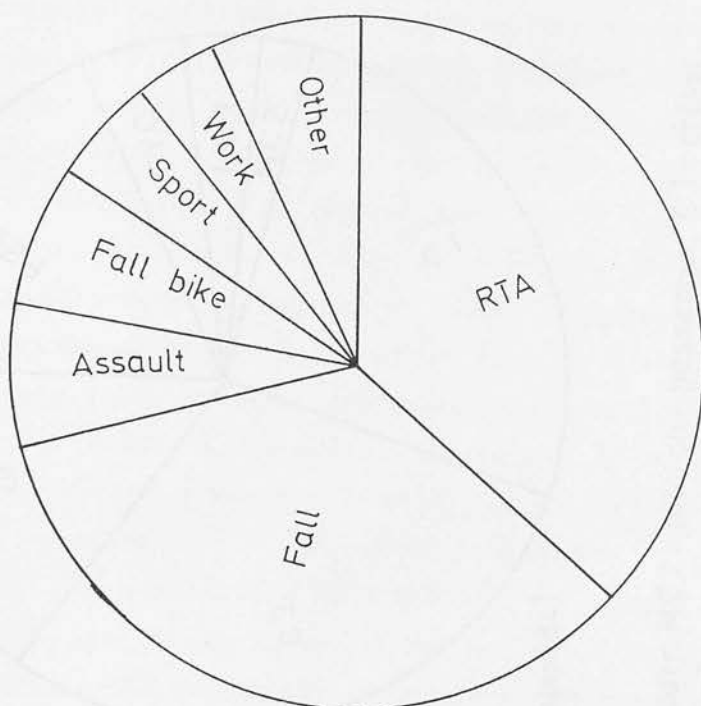
road traffic accidents. For complicated injuries only, ten of ninety males had recently consumed alcohol, in two cases the cause of injury was a fall and in the remainder a road traffic accident was responsible - 1 pedestrian, 2 motor-cycle riders, 1 pillion-passenger and 4 car drivers. In females with uncomplicated injury, nineteen (7.6%) were associated with drinking, 37% being assaults and 53% falls. In complicated injuries in women only four cases had been drinking - 3 falls and 1 car driver. Recent consumption of alcohol was significantly more common among adult admitted patients (15.8%) than among all adult attenders with head injury (9.2%) (chi-squared = 23.47, p less than 0.0005).

1.3% of all admitted head injuries were epileptics and were slightly more often males than females. Apart from one male cyclist involved in a road traffic accident, these patients were injured in falls. Three-quarters of them had uncomplicated injuries. There was no significant difference between the proportion of epileptics in the admitted group (1.3%) and that in all attenders (0.8%) (chi-squared = 1.58, p greater than 0.1).

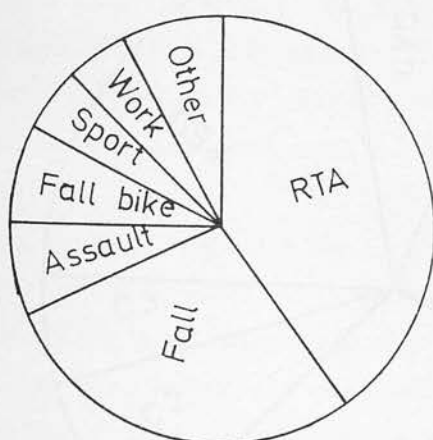
Treatment at the scene by the Flying Squad occurred on twelve occasions involving ten males and two females. In three-quarters of these patients complicated injuries existed, all were injured in road traffic accidents - 2 pedestrians, 2 motor cycle riders, 4 car drivers, 3 front-seat and 1 rear-seat passenger.

iii. Causes:

The proportion due to all causes for the whole population of admitted head injuries and for males and females separately is shown in Figure 3.15. Overall, road traffic accidents were slightly more common than falls and these two causes accounted for more than 70% of the total. When however, patients were classified by sex, the importance of road traffic accidents as a cause in males became readily apparent since 40% of head injury admissions in males resulted from road traffic accidents and only 28% from falls. Conversely 49% of female admissions resulted from falls and 29% from



All patients (928)

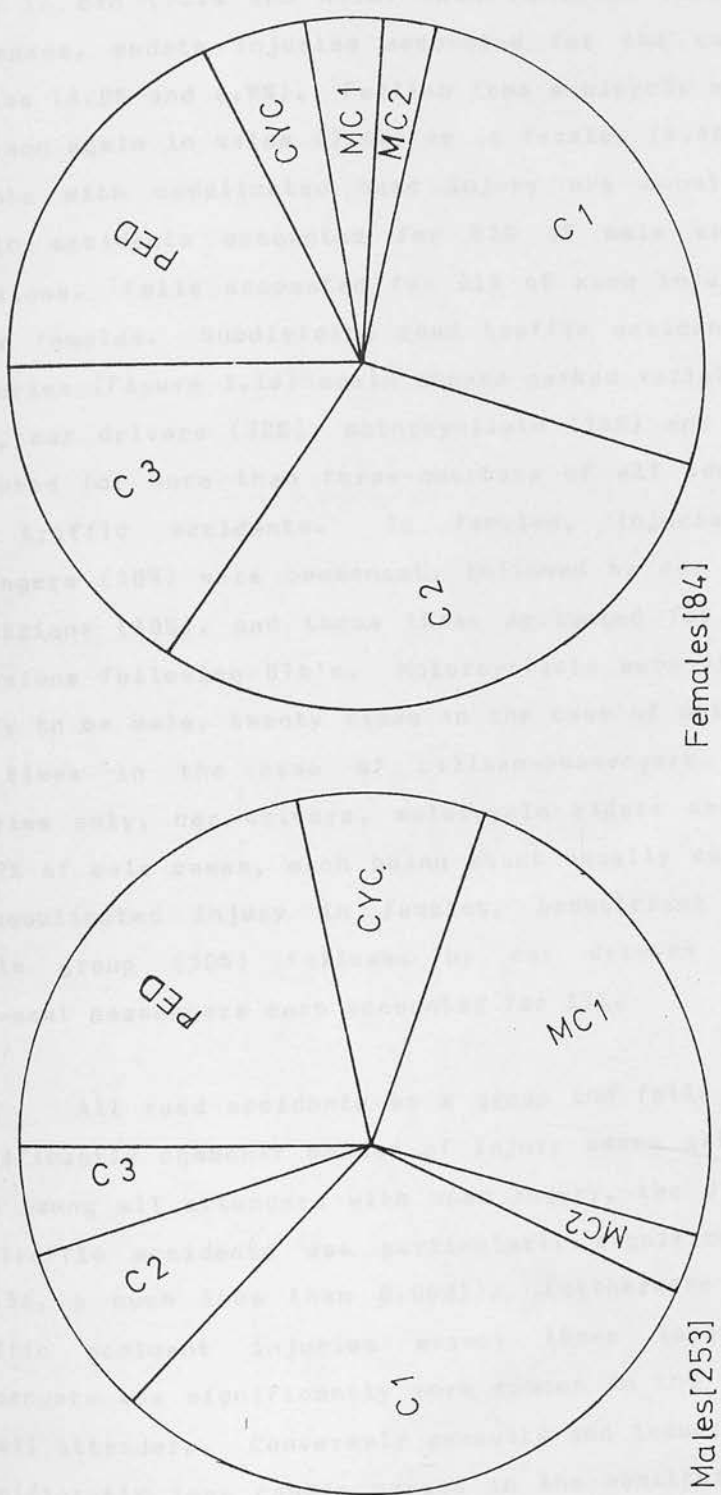


Males (635)



Females (293)

Figure 3.15 Causes of Head Injury admissions 1976-1977



(PED=pedestrian, CYC=cyclist, MC1=motorcycle rider, MC2 = pillion - passenger, C 1 = driver, C 2 = front -seat passenger, C 3 = rear - seat passenger)

Figure 3.16 Classification of RTAs

road traffic accidents. Other causes accounted for very few cases. Assaults and industrial injuries as expected are relatively more common in men (7.1% and 4.9%) than in women (6.1% and 1.7%). In both sexes, sports injuries accounted for the same proportion of injuries (4.8% and 4.9%). Falling from a bicycle was more than half as common again in males (7.6%) as in females (4.4%). If only those patients with complicated head injury are considered, then road traffic accidents accounted for 82% of male and 51% of female admissions. Falls accounted for 11% of such injuries in males but 38% in females. Subdividing road traffic accidents into different categories (Figure 3.16) again showed marked variation with sex. In males, car drivers (30%), motorcyclists (24%) and pedestrians (22%) accounted for more than three-quarters of all admissions following road traffic accidents. In females, injuries to front-seat passengers (30%) were commonest, followed by car drivers (26%) and pedestrians (18%), and these three accounted for three-quarters of admissions following RTA's. Motorcyclists were thirteen times more likely to be male, twenty times in the case of motorcycle riders and 3.5 times in the case of pillion-passengers. For complicated injuries only, car drivers, motorcycle riders and pedestrians made up 82% of male cases, each being about equally common. In the case of complicated injury in females, pedestrians were the biggest single group (30%) followed by car drivers (22%), front and rear-seat passengers each accounted for 17%.

All road accidents as a group and falls from bicycles were significantly commoner causes of injury among all admitted patients than among all attenders with head injury, the difference in regard to traffic accidents was particularly significant (chi-squared = 190.56, p much less than 0.0005). Furthermore each sub-group of traffic accident injuries except those incurred by rear-seat passengers was significantly more common in the admitted group than in all attenders. Conversely assaults and industrial accidents were significantly less common causes in the admitted group than in all attenders.

Breakdown of causes according to age and sex is shown in

Table 3.9. Falls were more common in children and the elderly and at all ages were commoner in females. 82% of uncomplicated injuries and 46% of complicated injuries in women over sixty-four years resulted from falls. Industrial injuries were, not surprisingly, confined to the working population and were more than twice as common in men as in women. Assaults caused only uncomplicated head injuries and 64% of assaults in men and a third of assaults in women occurred in 15-24 year olds. The overall sex ratio for assaults was 2.3. Injuries during sporting activity occurred more often in adults than children and not at all in the elderly. Only three out of the total of forty-five sports injuries resulted in a complicated

AGE CAUSE	ALL AGES n=928		0 - 14YEARS n=313		15 - 64YEARS n=535		65 + YEARS n=80	
	M%	F%	M%	F%	M%	F%	M%	F%
ASSAULT	7.1	6.1	1.4	0	11	12	0	0
INDUSTRIAL	4.9	1.7	0	0	8.1	3.2	0	0
SPORT	4.9	4.8	4.1	4.3	5.8	6.5	0	0
FALL	28	49	45	60	17	34	48	72
FALL BIKE	7.6	4.4	13	14	4.2	0	6.1	0
PEDESTRIAN	8.7	5.1	13	4.3	5.2	3.2	21	13
CYCLIST	3.5	1.4	6.3	2.2	1.8	0.6	3.0	2.1
MOTORCYCLIST	9.6	1.0	0	0	16	1.9	3.0	0
PILLION	1.1	0.7	0	0	1.8	1.3	0	0
CAR DRIVERS	12	7.5	0	0	19	14	12	2.1
F. PASSENGER	3.1	8.5	0	0	4.7	15	6.1	4.3
R. PASSENGER	1.9	4.4	1.4	3.3	2.4	5.8	0	2.1
OTHER	7.7	5.8	16	12	3.7	2.6	0	4.3
TOTAL [100%]	635	293	221	92	381	154	33	47

Table 3.9 Causes of head injury by age-groups and sex: Admitted patients 1976-1977

injury. More than half of sports injuries occurred in 15-24 year olds and more than three quarters in 10-24 year olds. The male/female ratio for sports injuries was 2.2. Falling off bicycles occurred at all ages in males but only in children in females. Overall, this type of injury was commonest in 5-14 year olds, 62% of males and all females being in this age group. The male/female ratio was 3.6. No complicated injuries were caused by falls from bikes.

Among pedestrians children predominated, contributing 46% to the total. Adults accounted for 36% and elderly patients 19%. However this type of injury was a more common cause of admission in the elderly than in either adults or children. The overall sex ratio was 3.7 and the male excess was most marked in children where the ratio was 7.0 and least marked in the elderly where it was 1.2. More than a third of pedestrians had other injuries in addition to their head injury.

Cyclists were most often young, 46% were aged 10-14 years, and were more often boys (male/female ratio 3.3). A fifth had complicated injuries. Motorcycle accidents leading to admission were almost exclusively confined to young men. Of sixty-four motorcycle riders of both sexes, 55% were 15-19 year old males and of nine pillion-passengers, 56% were similarly aged young men. A third of riders and 44% of pillion-passengers had an additional reason for admission as well as their head injury. The male/female ratio was 20.3 for motorcycle riders and 3.5 for pillion-passengers.

Peak incidence among car drivers occurred at 20-24 years, 30% of males and 36% of females being in this age group. The overall sex ratio was 3.5. A little over a quarter of drivers had complicated injuries and the male/female ratio for all these patients was 4.3. Front-seat passengers were more often women (male/female ratio 0.8). More than a half were aged 15-24 years, 29% being 15-19 year olds and 22% being 20-24 years old. About a seventh had additional reasons for admission. Women were also more often rear-seat passengers (male/female ratio 0.9). A third of all

rear-seat passengers were in their late teens and a similar proportion had complicated injuries.

iv. Temporal Relationships:

The hourly distribution of patients according to sex is shown in Figure 3.17. 41% of all patients with head injury who were admitted presented to the AED between 09.00 and 17.00 (39% males and 47% females) and 41% between 17.00 and 24.00 hours (43% males and 38% females). Children were more likely than adults to present during the daytime, particularly girls, 54% of whom presented between 09.00 and 17.00 hours compared with 46% of boys. Patients with complicated injuries presented more often between 17.00 and 09.00 hours the next day, this being the case in 58% of males and 51% of females. 53% of females and 61% of males with uncomplicated injury presented out of office hours. In children out of hours presentation was consistently commoner in boys whether they had complicated injuries or not. In girls 50% of those with complicated injury presented out-of-hours compared with only 45% of patients with uncomplicated injury. In boys and girls out-of-hours presentation was more common in the case of complicated than of uncomplicated injury, a reversal of the overall pattern.

Dividing the hourly distribution for all admitted patients into equal periods of three hours (07.00-09.59, 10.00-12.59 etc) and then comparing this with the distribution for all attenders revealed that the distributions were significantly different (chi-squared = 37.59, D.O.F = 7, p less than 0.0005). This was due largely to an over-representation of 37% for the period 22.00 - 00.59 in the admitted group and to a lesser extent to an under-representation of 24% for the period 10.00-12.59 as well as an over-representation of 38% in the period 01-00-03.59.

In children two peaks were apparent, the first at 12.00-13.00 hours and a second and higher peak in the early evening at 17.00-19.00 hours. Considering all males together, succeedinglly higher peaks occurred in the morning (10.00-11.00 hours), at

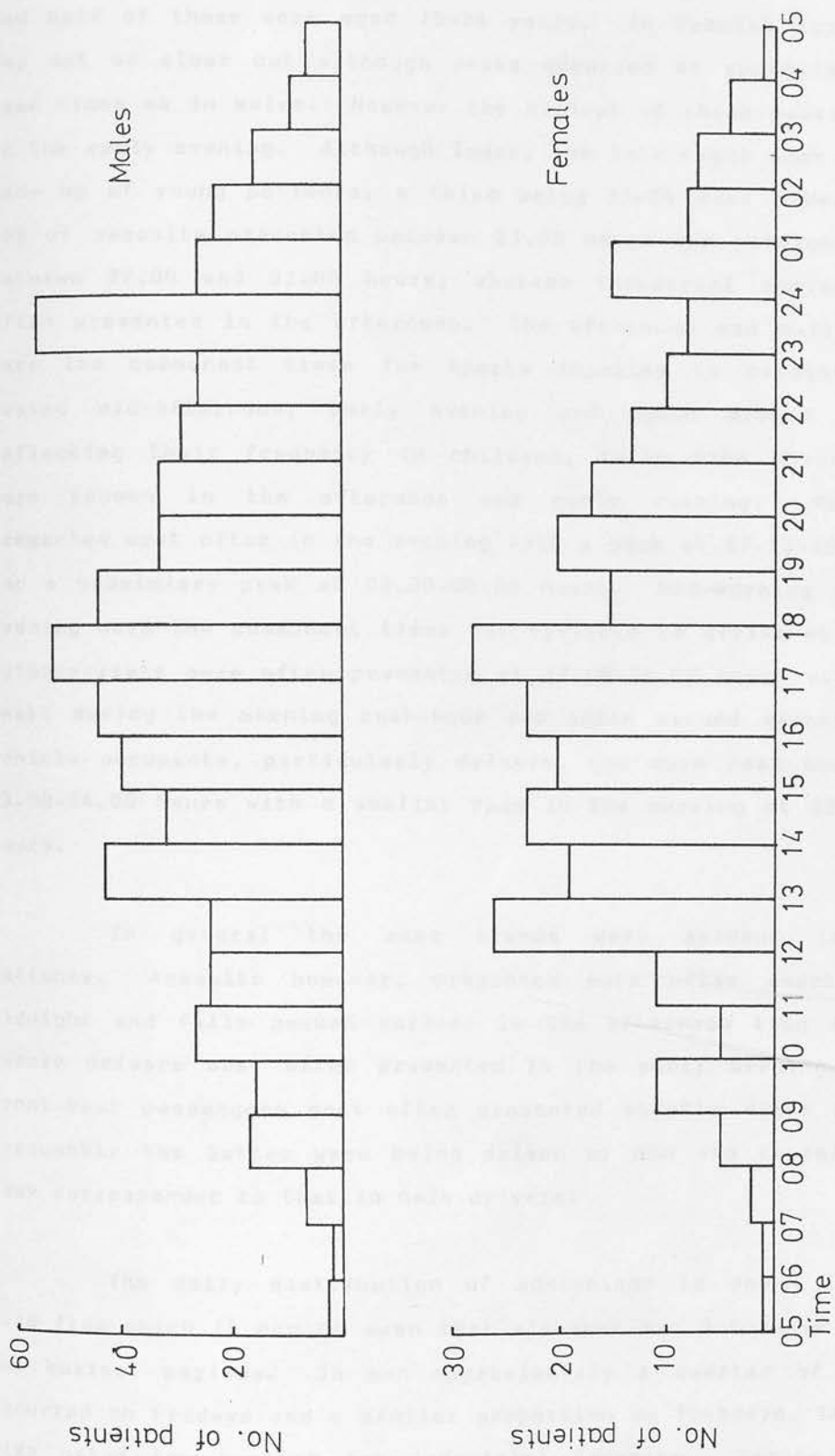


Figure 3.17 Hourly distribution of admissions 1976-1977

lunchtime (13.00-14.00 hours) in the early evening (17.00-18.00 hours) and late at night (23.00-24.00). 10% of all males with uncomplicated head injury presented between 23.00 hours and midnight and half of these were aged 15-24 years. In females the position was not as clear cut although peaks occurred at approximately the same times as in males. However the highest of these peaks occurred in the early evening. Although lower, the late night peak was again made up of young patients, a third being 15-24 year olds. In men 29% of assaults presented between 23.00 hours and midnight and 62% between 22.00 and 02.00 hours, whereas industrial accidents most often presented in the afternoon. The afternoon and early evening were the commonest times for sports injuries to present. Falls peaked mid-afternoon, early evening and again around midnight. Reflecting their frequency in children, falls from bicycles were more common in the afternoon and early evening. Pedestrians presented most often in the evening with a peak at 19.00-20.00 hours and a subsidiary peak at 08.00-09.00 hours. Mid-morning and early evening were the commonest times for cyclists to arrive at the AED. Motorcyclists more often presented at 17.00-18.00 hours with lesser peaks during the morning rush-hour and again around midnight. For vehicle occupants, particularly drivers, the main peak occurred at 23.00-24.00 hours with a smaller rise in the morning at 09.00-10.00 hours.

In general the same trends were evident in female patients. Assaults however, presented more often shortly after midnight and falls peaked earlier in the afternoon than in males. Female drivers most often presented in the early evening, whereas front-seat passengers most often presented shortly after midnight. Presumably the latter were being driven by men and therefore this peak corresponded to that in male drivers.

The daily distribution of admissions is shown in Figure 3.18 from which it can be seen that mid-week and Saturdays were the two busiest periods. In men approximately a quarter of assaults occurred on Fridays and a similar proportion on Tuesdays, the latter also being the busiest for industrial injuries. Sports injuries

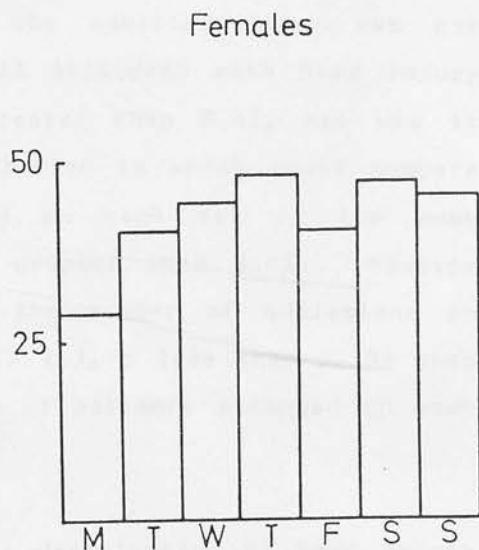
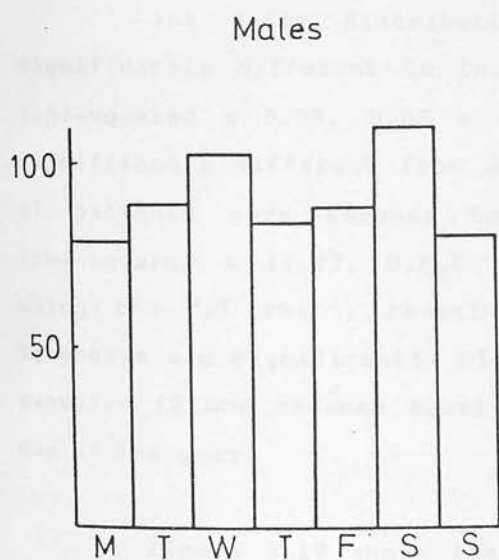
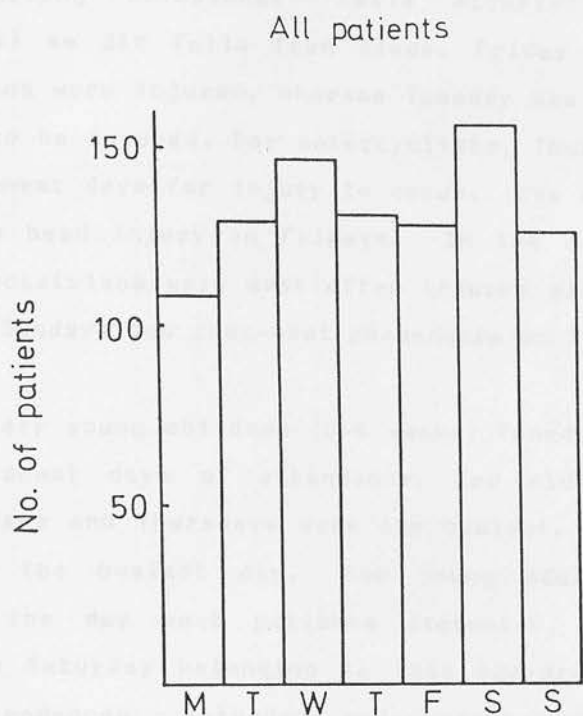


Figure 3.18 Daily distribution of admissions 1976-1977

peaked mid-week and at weekends in keeping with the timing of organised sporting occasions. Falls occurred most often on Saturdays (22%) as did falls from bikes. Friday was the day when most pedestrians were injured, whereas Tuesday was the commonest day for cyclists to be injured. For motorcyclists, Thursday and Saturday were the commonest days for injury to occur. Car drivers most often presented with head injury on Fridays. In the case of women, car drivers and pedestrians were most often injured mid-week, front-seat passengers on Sundays and rear-seat passengers on Thursdays.

For very young children (0-4 years) Tuesdays and Wednesdays were the commonest days of attendance, for older children (5-14 years) Wednesdays and Thursdays were the busiest. For all children Wednesday was the busiest day. For young adults (15-24 years) Saturday was the day most patients presented, 38% of all male attendances on Saturday belonging to this age-group as did 19% of all female attendances. Saturdays and Sundays were the busiest for other adults. For all adults, Saturday was the commonest day of presentation.

The daily distribution in the admitted group was not significantly different to that in all attenders with head injury (chi-squared = 5.99, D.O.F = 6, p greater than 0.4), nor was it significantly different from a distribution in which equal numbers of patients were assumed to attend on each day of the week (chi-squared = 11.23, D.O.F = 6, p greater than 0.05). However using the "zI test", revealed that the number of admissions on Saturdays was significantly higher ($z = 2.3$, p less than 0.05) than expected if one assumed equal numbers of patients attended on each day of the year.

Figure 3.19 shows the monthly distribution of head injury admissions. Overall more admissions took place in the summer and autumn and this was most marked in males, where a three month peak occurred from July to September. In females, admissions in general were higher in the summer months but reached their highest level in October when they were 50% above the next highest month. Complicated

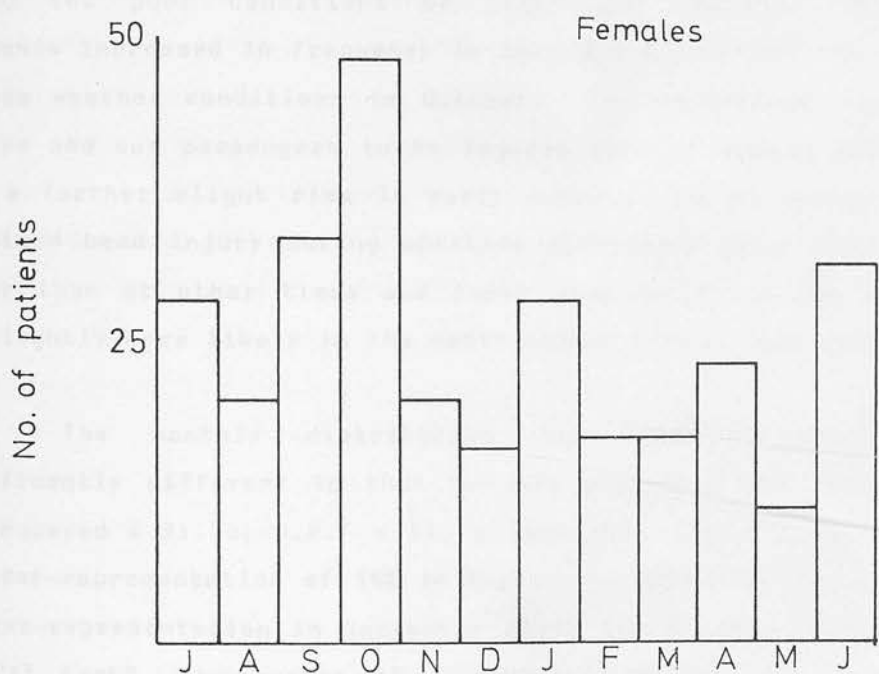
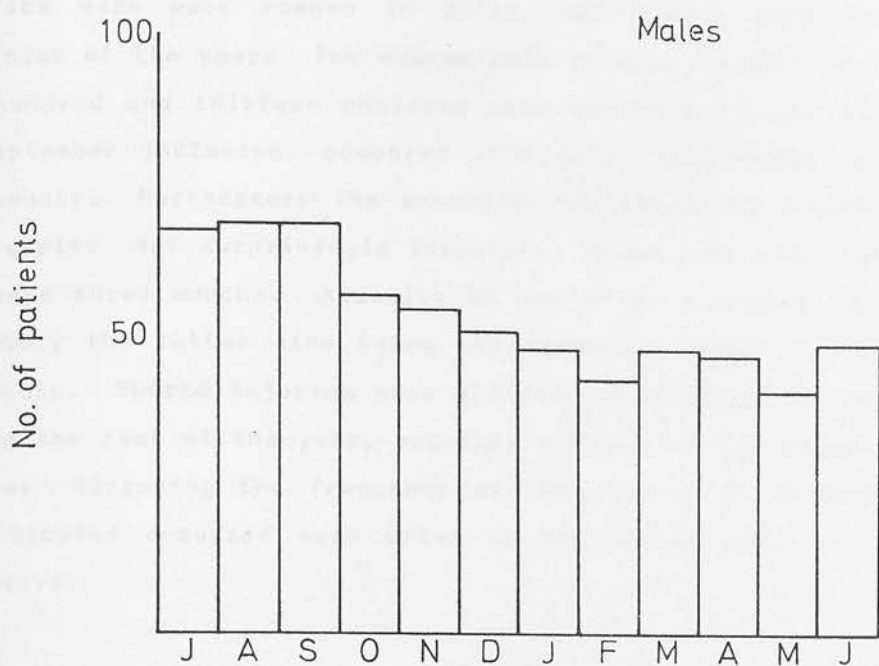


Figure 3.19 Monthly distribution of admissions 1976-1977

injuries were more common in autumn and winter than during the remainder of the year. The summer peak is most evident in children, one hundred and thirteen children were admitted in the months July to September inclusive, compared with only fifty-seven in November to January. Furthermore the summer/winter ratio was higher in boys than girls. Not surprisingly therefore, falls were also commoner in the same three months. Assaults in men often occurred in July and November, the latter also being the commonest month for industrial accidents. Sports injuries were a little more common in autumn than during the rest of the year, possibly related to the start of a new season. Mirroring the frequency of this cause in children, falls from bicycles occurred more often in the months July to September inclusive.

RTA's which involved cyclists were more frequent in January and February, possibly as a result of newly acquired machines ridden during the poor conditions of light and weather. Motorcycle accidents increased in frequency in July and again with the onset of adverse weather conditions in October. The predominant months for drivers and car passengers to be injured were in autumn and winter, with a further slight rise in early summer. Unlike males, females sustained head injury during sporting activities more often in the summer than at other times and their involvement in car accidents was slightly more likely in the early summer than in the winter.

The monthly distribution for admitted patients was significantly different to that for all attenders with head injury (chi-squared = 31.34, D.O.F = 11, p less than 0.001) largely due to an under-representation of 38% in May in the admitted group, as well as over-representation in September (25%) and October (28%). Using the "zI test", the number of attendances in May was significantly lower and in September and October was significantly higher than expected assuming equal numbers of admissions occurred on each day of the year. The numbers for July just failed to show a significant difference ($z = 1.93$, p less than 0.1, greater than 0.05).

v. History Symptoms and Signs:

76% of admitted patients had been knocked out at the time of injury and this was equally common among males and females but more common in those with additional reasons for admission (84% males and 80% females). 18% had not been knocked out and in the remainder this fact was not recorded. Of all A&E attenders 886 initially lost consciousness, 703 (79%) of these were admitted, 128 (14%) were not admitted, 41 (4.6%) took their own discharge and 2 returned to the A&E department and were again discharged. The remaining 12 were admitted for reasons other than their head injury and loss of consciousness was due to another condition for example CVA. Those knocked out and not admitted were late presentations. Males who took their own discharge were usually involved in assaults and females in falls. A period of unconsciousness was less common in children, 59% of whom had and 36% of whom had not been knocked out. Of twenty-four children with additional reasons for admission (i.e., complicated head injury as defined earlier) two-thirds had been rendered unconscious at the moment of injury. 85% of admitted patients over sixty-four years old had been knocked out.

Only two-thirds of patients injured in falls lost consciousness initially, compared with 94% of motorcycle riders and all pillion-passengers. Initial loss of consciousness occurred in 75% of cases resulting from falling off bicycles, 80% of sports injuries, 83% of assaults and 89% of industrial accidents. RTA's were in general associated with a higher proportion of patients who sustained an initial loss of consciousness - 83% pedestrians, 84% car drivers, 87% of front-seat passengers, 88% of rear-seat passengers and cyclists.

Amnesia occurred in 35% of all head injury admissions and was absent in 4%. As used here this term indicates a gap in memory related to the time of injury and apparent when the patient was first examined in the A&E department. Amnesia was less common in children (23%) and more common in males (36%) than females (31%). 44% of patients over sixty-four years old were amnesic. The relationship between the presence of amnesia and the cause of injury followed the same general pattern to that detailed above for

patients knocked out, being less common for causes more frequent in childhood (falls and falls from bikes) and more common in the victims of road traffic accidents.

21% of patients experienced vomiting after their injury and this was commoner in females (24%) than males (20%) and in patients with uncomplicated injuries (23%) more than in patients with complicated head injury (9.6%). Vomiting was much commoner in children (41%) than adults (11%). Consequently childhood causes of head injury were more often associated with vomiting.

Early epilepsy occurred in eleven patients, all with uncomplicated head injury. Ten were males, six were under fifteen years of age and nine under twenty years of age. Children aged 2-4 years accounted for 36% of the total. These patients represented 1.2% of head injury admissions. Falls were responsible for the injury in five cases, two were pedestrians and industrial accidents, falling from a bicycle, motor-cycle riders and other causes each accounted for one patient.

A little less than a quarter of all head injury admissions had neurological signs, 22% of males and 29% of females. Signs were commoner in patients with complicated head injury (32%) and again more so in females (35%) than in males (30%). Either no or an inadequate CNS examination was found in 7.9% of patients, again a little more often in females and twice as often in those with complicated head injury. 68% had no neurological signs (70% males and 62% females). Definite absence of signs was more common in patients with head injury alone (71%) than in patients with additional reasons for admission (52%). Signs occurred in a third of children and a fifth of adults and among children were commoner in girls (40%) than boys (29%). 285 (5%) of all A&E attenders had neurological signs, 183 (64%) of these were admitted because of head injury alone, 43 (15%) because of head injury and another injury or condition, 14 (4.9%) because of another injury or condition only and of the remaining 45 patients, forty-one were discharged and 4 took their own discharge. In the 41 patients who were discharged,

drowsiness was noted at the time of initial examination, however, these patients were not detained for observation. Cyclists were the group who most often had signs present (38%) and assaults least often (7.9%). Generally, road traffic accidents had a larger proportion with signs. 19% of car drivers, 22% of front-seat passengers and motor-cycle riders, 26% of pedestrians and 28% of rear-seat passengers, 13% of sport injuries, 17% of industrial accidents, 22% of those falling from bikes and 31% of falls had signs present.

vi. Plain X-Ray:

A radiologically apparent skull fracture was present in eighty-one admitted patients (8.7%) and was equally common among males and females overall, although more common in patients of both sexes with additional reasons for admission (11% vs 8.3%). 12% of children had a skull fracture compared with 7.0% of all adults, 6.4% of patients aged 15-64 years and 11% of patients aged sixty-five years and over. A half of girls with additional reasons for admission had a skull fracture compared with a sixteenth of boys with additional reasons. For adults with additional reasons for admission, 10% of men and 4% of women had a fracture and for elderly patients a third of men and no women with additional reasons for admission had a fracture. 22% of all patients with skull fracture on X-ray were aged 0-4 years, 15% were aged 5-9 years, 9.9% 10-14 years and 56% were under twenty years old.

A little over a third of fractures were due to falls and nearly all resulted in uncomplicated injury. Falls accounted for more fractures in females than males (42% and 31% respectively). 8.8% of all patients admitted following a fall had a skull fracture, however more males than females injured in falls had a skull fracture (9.6% and 7.7% respectively). No rear-seat passengers and only one pillion-passenger had a fracture on X-ray. The proportion of patients with skull fracture varied for different causes from none, in rear-seat passengers to 19% for cyclists and 33% for cases of non-accidental injury. No females sustained a skull fracture at

work, falling from a bicycle or as front-seat passengers. No males sustained a fracture as pillion-passengers or as a result of non-accidental injury. A higher proportion of females sustained fractures than males in sport injuries and assaults, as cyclists, motorcyclists, pillion-passengers and as the result of non-accidental injury.

Fractures were commoner among all victims of road traffic accidents (16% pedestrians, 19% cyclists, 7.7% motorcycle riders, 9.1% pillion-passengers, 8.2% drivers, 4.8% front-seat passengers) than other causes (3.2% assaults, 14% industrial, 11% sport, 8.8% falls, 4.9% fall from bike, and 33% NAI). Six motorcyclists had skull fractures, in three cases a helmet was worn and in the remainder this fact was not recorded. Eight car drivers had a skull fracture, in five cases no seat belt was worn and in three this fact was not recorded. Two front-seat passengers had skull fractures, one wore a seat belt but in the other this fact was not recorded.

41% of patients with skull fracture presented between 09.00 and 17.00 hours (38% males and 46% females). In males nearly a quarter of patients with skull fracture presented between 18.00 and 20.00 hours and 44% between 17.00 hours and midnight. In females a fifth of cases with skull fracture presented in the hour between 17.00 and 18.00 hours and 38% between 17.00 hours and midnight. In males the least number of fractures occurred on Saturdays (7.3%) and most on Thursdays (18%) with little difference between the remaining days. In females most fractures occurred on Sundays (19%) with little difference during the rest of the week, except that fractures were commoner towards the end of the week. August had 30% more fractures than any other month and the number of fractures in summer was approximately two and a half times the number in winter.

vii. Reasons for Admission:

Three broad categories of admission were recognised;

- | | |
|--|--------------|
| a) Admitted because of head injury alone | 793 patients |
|--|--------------|

- b) Admitted because of head injury and another injury or condition 135 patients
- c) Admitted because of another injury or condition alone 179 patients

Those patients in groups a and b have already been characterised in sections i-vi above. Table 3.10 below shows the

	HEAD INJURY ONLY			HEAD INJURY & OTHER			OTHER ONLY		
REASON FOR									
ADMISSION	M	F	ALL	M	F	ALL	M	F	ALL
n=	545	248	793	90	45	135	112	67	179
SYMPTOMS	86	39	125	3	2	5			
KNOCKED OUT	406	186	592	76	36	112			
AMNESIA	195	83	278	29	8	37			
? SKULL #	19	14	33	4	3	7			
SKULL #	44	20	64	9	3	12			
SIGNS	113	61	174	22	10	32			
FIT	10	1	11						
SURGICAL				32	11	43	24	11	35
ORTHOPAEDIC				51	20	71	34	15	49
OPHTHALMIC				1		1	7	1	8
ENT				2		2	2	2	4
DENTAL				7		7	4	2	6
MEDICAL				2	7	9	11	14	25
GERIATRIC				1	2	3	4	8	12
OTHER				4	7	11	31	18	49
ALL REASONS	873	404	1277	243	109	352	117	71	188

(# = Fracture)

Table 3.10 Reason for admission in the three broad groups: 1976-1977

reasons for admission according to sex for each of the three categories. The commonest reason for admission in the head-injured group (a+b) was loss of consciousness at the time of injury, present in 76% of admissions and equally common in males and females but more common in patients in group b (83%) than in group a (75%). For patients with head injury only there were 1.61 reasons for admission per patient. For patients with head injury plus another condition and other conditions only, there were 2.61 reasons per patient and 1.05 reasons per patient respectively, thus suggesting that multiple reasons for admission were most often related to the head injury and few patients had more than two reasons for admission e.g., head injury plus abdominal trauma plus orthopaedic trauma. For patients in group b trauma other than that to the head accounted for 84% of the 147 reasons for admission excluding those concerned with head injury. Among these same patients road traffic accidents were responsible for most of the surgical (93%) and orthopaedic (82%) reasons for admission. Car drivers were particularly likely to have general surgical problems in addition to their head injury while pedestrians and motorcyclists were more likely to have additional orthopaedic problems. Non-traumatic additional reasons for admission most often occurred in those patients who sustained their head injury as a result of falling when they were associated with syncopal episodes, strokes and other causes of 'collapse'.

For patients admitted because of other injuries or conditions only, general surgical and orthopaedic trauma together with injuries to the eyes and facial skeleton accounted for 55% of the reasons for admission. Road traffic accidents contributed to the bulk of surgical (54%) and orthopaedic cases (73%) with the same relationship to car drivers (surgical) and pedestrians and motorcyclists (orthopaedic) as found in the patients in group b. Medical conditions were associated largely with falls, particularly in women. Thus among patients with medical and other conditions, 63% of females and 54% of males were injured in falls. Nearly half with eye injuries and a third with facio-maxillary injuries were involved in sports accidents.

viii. Treatment:

The setting up of a drip was required for one hundred and twenty-five patients and two-thirds of these had been knocked out, twenty-three had a skull fracture and a third had neurological signs on admission. Four male patients from this group experienced early post-traumatic epilepsy. One third had orthopaedic injuries sufficient to warrant orthopaedic admission in their own right and a slightly larger proportion had additional general surgical problems. Only five (4%) had general medical conditions.

The use of plasma expanders was necessary in twelve patients, three-quarters of whom had been knocked out, a third had neurological signs on admission, but only one had a skull fracture. However two-thirds had additional general surgical problems as well as their head injury and a third had additional orthopaedic problems. Blood transfusion in the A&E department was required in ten patients, all male. Six had been knocked out, three had neurological signs and one had a skull fracture on X-ray. Additional general surgical problems occurred in eight of these ten patients and additional orthopaedic problems in four.

Thirty-eight patients were admitted to the Intensive Care Unit, thirty-three of these had been knocked out, twenty-eight had neurological signs and seventeen had skull fractures. Early post-traumatic epilepsy occurred in five patients. Twenty-six of the thirty-eight patients were injured in road traffic accidents. The male/female ratio was 2.8. A quarter of the males were aged 15-19 years and 42% of all 38 patients were under twenty years of age.

Insertion of a chest drain was performed in seventeen patients, nearly two-thirds of whom had been knocked out. Three had a skull fracture on X-ray and six had neurological signs on admission. All had additional general surgical problems and three had orthopaedic problems in addition to their head injury. The male/female ratio in this group was 3.25.

Seventeen patients required endo-tracheal intubation, two-thirds had been knocked out and the same proportion had neurological signs on admission. Seven had skull fractures on plain X-ray. One male patient had early post-traumatic epilepsy. Almost a half had additional general surgical problems as well as their head injury and one male patient had a facio-maxillary injury itself warranting admission. The male/female ratio was 3.1.

Peritoneal lavage was performed on eleven occasions. Nine of these patients had been knocked out, two had neurological signs and only one had a skull fracture. More than a quarter had additional orthopaedic problems. The male/female ratio was 4.5.

Dexamethasone was administered to thirty patients, twenty-five of whom had been knocked out and two thirds of whom had neurological signs on admission. A half had a skull fracture on X-ray. Five patients, all male, developed early post-traumatic epilepsy. One sixth had additional general surgical problems and a sixth additional orthopaedic problems. Only six patients were given intravenous mannitol, five males and 1 female, all had been knocked out and 5 had neurological signs. Three of these six patients had radiologically apparent skull fractures and one patient had early epilepsy. Two males had additional general surgical and a further two males had additional orthopaedic problems.

General anaesthesia within twenty-four hours of head injury was carried out in ninety-six patients, forty of whom had been knocked out and four had skull fractures. 9% had neurological signs on admission. Most general anaesthetics were for manipulation of fractures and forty-one patients had orthopaedic injuries themselves warranting admission. Many of the remainder had fractures which although not meriting admission in their own right still required reduction. Biers Block was not used at the time of this study. Ophthalmic injuries contributed a small proportion to the number requiring early general anaesthetic.

ix. Length of Stay:

The cumulative percentage discharges for each of the three broad groups of admitted patients are shown in Figure 3.20. For patients with head injury only, 61% were discharged by the end of the first day and 81% by the end of the first forty-eight hours. Only 4% stayed longer than one week and only 0.5% longer than one month. There was a slight tendency for females to remain between four days and two weeks more often than males. Children stayed for a shorter period, only 3% staying longer than a week. No male who was assaulted stayed longer than three days and no female longer than ten days. All patients staying longer than one month were involved in road traffic accidents and more than a half staying more than one week and upto one month were also the victims of road traffic accidents. 71% of assaults and the same proportion of industrial accidents were discharged by the end of the first twenty-four hours.

For patients admitted because of head injury plus another injury or condition, 13% were discharged in the first twenty-four hours and 21% by the end of the first two days. 53% remained in hospital longer than one week and a quarter longer than one month. Once again there was a tendency for more females to stay in the short term (upto two weeks) than males and also in the medium term (one to two months) whereas males stayed longer than three months more often than females (7% males and 4% females). In males, stay longer than three weeks only occurred in patients injured in road traffic accidents, especially car drivers and pedestrians. In females, stay beyond one week occurred in the victims of RTA's and falls only. The earlier discharge of children was not apparent in this group of patients, however, no boys under five years of age stayed longer than six weeks.

Patients with other injuries or conditions alone determining admission were intermediate in the time relationships of their discharge compared with the above groups. More males were discharged in the first twenty-four hours than females (33% vs 30%). By the end of the first forty-eight hours the proportions were equal, however 33% of females stayed longer than one week

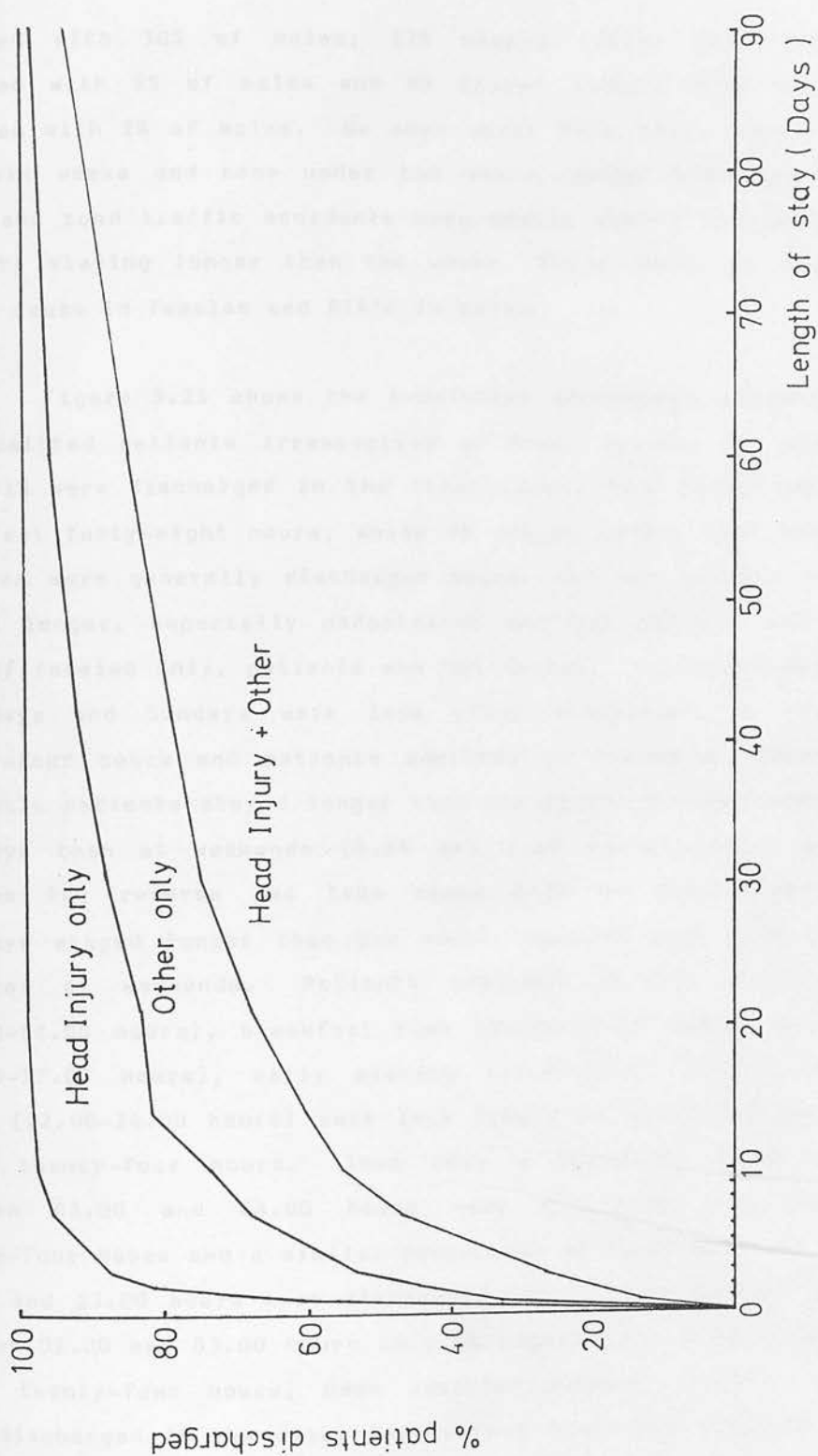


Figure 3.20 Cumulative percentage discharges of the 3 groups of patients

compared with 30% of males; 17% stayed longer than one month compared with 9% of males and 8% stayed longer than two months compared with 2% of males. No boys under five years stayed longer than six weeks and none under ten years longer than two months. Falls and road traffic accidents were nearly always responsible for patients staying longer than two weeks, falls being an especially common cause in females and RTA's in males.

Figure 3.21 shows the cumulative percentage discharges for all admitted patients irrespective of their reason for admission. Only 51% were discharged in the first twenty-four hours and 68% in the first forty-eight hours, while 5% stayed longer than one month. Children were generally discharged sooner and the victims of RTA's stayed longer, especially pedestrians and car drivers and in the case of females only, patients who had fallen. Patients admitted on Saturdays and Sundays were less often discharged in the first twenty-four hours and patients admitted on Thursdays, more often. More male patients stayed longer than one month who were admitted on weekdays than at weekends (4.8% and 3.6% respectively) while in females the reverse was true since 6.3% of those admitted on weekdays stayed longer than one month compared with 8.5% of those admitted at weekends. Patients admitted in the early morning (02.00-04.00 hours), breakfast time (08.00-09.00 hours) lunch time (12.00-13.00 hours), early evening (17.00-18.00 hours) and late night (22.00-24.00 hours) were less likely to be discharged in the first twenty-four hours. Thus only a third of males admitted between 03.00 and 04.00 hours were discharged in the first twenty-four hours and a similar proportion of those admitted between 22.00 and 23.00 hours were discharged early. For females admitted between 02.00 and 03.00 hours only an eighth were discharged in the first twenty-four hours, none admitted between 08.00-09.00 hours were discharged in the first twenty-four hours and only 28% in the first week. A little more than a third of females admitted between 17.00 and 18.00 hours were discharged in the first twenty-four hours.

Again considering all admitted patients (groups a, b and c) initial unconsciousness did not prolong stay since consistently more

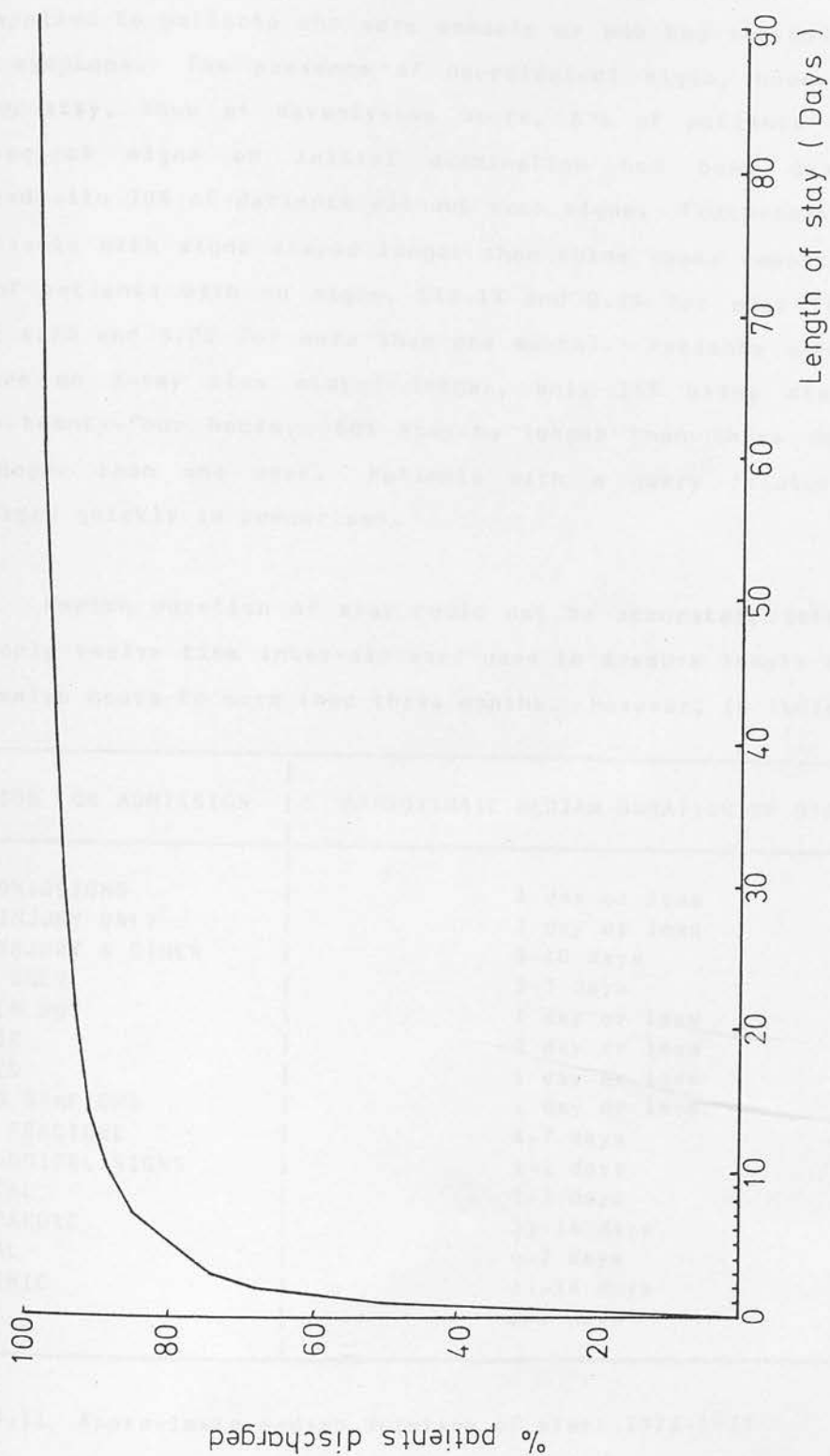


Figure 3.21 Cumulative percentage discharges of all admitted patients

patients with initial unconsciousness were discharged for every time interval e.g., at seventy-two hours 77% of those knocked out had been discharged compared with 70% of those not knocked out. The same applied to patients who were amnesic or who had vomited or had other symptoms. The presence of neurological signs, however, did prolong stay, thus at seventy-two hours, 63% of patients who had neurological signs on initial examination had been discharged compared with 78% of patients without such signs. Furthermore, 8.8% of patients with signs stayed longer than three weeks compared with 6.6% of patients with no signs, (12.1% and 8.2% for more than two weeks; 6.7% and 5.0% for more than one month). Patients with skull fracture on X-ray also stayed longer, only 14% being discharged within twenty-four hours, 60% staying longer than three days and 29% longer than one week. Patients with a query fracture were discharged quickly in comparison.

Median duration of stay could not be accurately determined since only twelve time intervals were used to measure length of stay from twelve hours to more than three months. However, in Table 3.11

REASON FOR ADMISSION	APPROXIMATE MEDIAN DURATION OF STAY
ALL ADMISSIONS	1 day or less
HEAD INJURY ONLY	1 day or less
HEAD INJURY & OTHER	8-10 days
OTHER ONLY	2-3 days
KNOCKED OUT	1 day or less
AMNESIC	1 day or less
VOMITED	1 day or less
EXCESS SYMPTOMS	1 day or less
SKULL FRACTURE	4-7 days
NEUROLOGICAL SIGNS	1-2 days
SURGICAL	2-3 days
ORTHOPAEDIC	11-14 days
MEDICAL	4-7 days
GERIATRIC	11-14 days
RTA	2-3 days

Table 3.11 Approximate median duration of stay: 1976-1977

the approximate median duration of stay for various categories of

patients are shown. From this it can be seen that orthopaedic problems and geriatric admissions were associated with the longest duration of stay. Also because of irregular time intervals the number of occupied bed-days could not be accurately determined. Nevertheless, all admissions led to 6887.5 bed days being utilised (6.2 per patient). For patients with head injury only, 1827.0 bed-days were occupied (2.3 per patient); for patients with head injury plus other, 3079.5 bed-days were occupied (22.8 per patient) and for patients with other only 1981.0 bed-days were occupied (11.1 per patient). For head injury alone (groups a+b) 4906.5 bed-days were occupied (5.3 per patient) representing about 11% of the total available in general surgery for Chester Royal Infirmary, but one quarter of all emergency general surgical admission.

3.2.5 Neurosurgical Events:

Nine (10%) of the eighty-nine patients with skull fracture on X-ray had depressed fractures and two of these were closed. One patient with a small, closed, depressed fracture was discharged with the fracture unrecognised on his skull X-ray. Subsequent enquiry revealed that he had come to no harm. The other patient with a closed depressed fracture had exploratory burr holes for a suspected mass lesion, none being found. The remaining seven patients all had compound fractures, one had simple suturing, one had no surgical treatment, one had burr holes for a suspected extradural haematoma and the depressed bone was removed during operation and four patients had surgical toilet and elevation of their fractures. Three of the latter four patients were transferred to the Regional Neurosurgical Unit for treatment. Seven of the nine with depressed fractures were male. Two patients were injured by metallic objects at work, two patients were car drivers (1 female), two were pedestrians, one elderly man sustained a closed depressed right temporal and a closed linear left occipital fracture when he fell downstairs, one young woman was injured when she fell from her horse and a twelve year old boy in falling off his bicycle struck his head against the end of the handle bars. The ages of the patients were 9 years (pedestrian), 12 years (fall from bike), 24 years (fall from horse), 35 years (hit by falling metal at work), 42 years (female car driver), 50 years (hit by falling metal at work), 50 years (pedestrian), 71 years (car driver) and 75 years (fall downstairs).

Fourteen patients were transferred to the Regional Neurosurgical Unit, representing 1.5% of all head injury admissions. Three of these, already referred to above, had compound depressed fractures and were transferred within hours of arrival at hospital. In the remaining eleven patients, abnormality of the conscious level was the commonest single reason for transfer. Usually this was manifest as a deterioration, but sometimes as a failure to improve. Either abnormality was present in eight patients and half also had lateralising signs. Three patients were transferred in the first twenty-four hours after arrival at hospital,

two in the next twenty-four hours, one patient on the fourth day, one after forty-three days and one patient was re-admitted three months later and transferred three weeks after that. Four of the eight patients had cerebral angiography and in none was an intracranial mass lesion found. One was later diagnosed as having a mitochondrial myopathy, two had burr holes without prior neuroradiological investigation and these revealed cerebral oedema only. In one patient a lateral ventricle tap via a burr hole revealed raised pressure and a drain was inserted. Finally, one patient was re-admitted in Chester three months after discharge following a head injury. Three weeks later he was transferred to the Regional Neurosurgical Unit where a chronic bilateral subdural haematoma was evacuated. Both of the latter two patients also had angiography. The three remaining patients who had neither a compound depressed fracture nor a deteriorating conscious level were transferred for excision of a sphenoid meningioma, clipping of a Berry aneurysm and treatment of a persistent CSF leak. The former two patients had cerebral angiography prior to operation.

Among those patients not transferred to the Regional Neurosurgical Unit, one underwent surgical toilet and elevation of a compound depressed fracture. A further patient, also with a depressed fracture, had an acute extradural haematoma underlying the fracture evacuated. This patient subsequently died and a subdural haematoma was found at post-mortem. Bilateral burr holes were performed on a man who suddenly deteriorated and had lateralising signs, however, no haematoma was found. At post-mortem an intracerebral haematoma was found in relation to a linear occipital fracture, this patient also had a closed depressed contralateral temporal fracture. Burr holes were also undertaken on another patient who experienced a respiratory arrest shortly after admission in coma and who had lateralising signs. On this occasion an acute subdural haematoma was found and evacuated.

As well as the patients described above, who developed post-traumatic intracranial haematomas, one further patient, a cyclist, unconscious from the time of injury, died forty-eight hours

after admission and a subdural haematoma was found at post-mortem. A total of five patients between them had seven post-traumatic intracranial haematomas if the patient with chronic bilateral subdural haematomas is counted as two haematomas. There was one patient with acute extradural (EDH) and subdural haematomas (SDH), two patients with acute subdural haematomas, one patient with an acute intracerebral haematoma (ICH) and one patient with chronic bilateral subdural haematomas. The incidence of the various types of post-traumatic haematoma determined from the results described, are given below:

Acute EDH	1.08/1000 admissions	3.8/1,000,000 population
Acute ICH	1.08/1000 admissions	3.8/1,000,000 population
Acute SDH	3.23/1000 admissions	11.5/1,000,000 population
Chronic SDH	1.08/1000 admissions	3.8/1,000,000 population

In addition to the complications, treatment and investigations just discussed, various other sequelae occurred and these are summarised in Table 3.12.

Depressed fracture [9/89]	2	closed	- 1 unrecognised
			- 1 had negative burr holes but ICH at post-mortem
	7	compound	- 1 no treatment
			- 1 simple suturing
			- 2 toilet & elevation in Chester
			- 3 toilet & elevation at Walton
Burr Holes	7		- 3 negative (2 had no skull fracture on X-ray)
			- 4 positive (2 had skull fracture)
Angiography	8		- 4 negative (no fracture on X-ray, 1 fractured base clinically)
			- 4 positive (none had fracture on X-ray)
Acute Subdural Haematoma (SDH)	3		All had fracture on X-ray; 1 also had EDH
Chronic Subdural Haematoma	1		Bilateral, no fracture
Acute Intracerebral Haematoma (ICH)	1		Depressed R temporal & linear L occipital fractures
Acute Extradural Haematoma (EDH)	1		Depressed fracture, also had subdural haematoma
Craniotomy/Fascia lata graft	2		1 also had polya gastrectomy for GIT bleeding
Evacuation of clot	3		1 acute EDH; 1 acute SDH; 1 chronic bilateral SDH
Clipping of Berry Aneurysm	1		
Excision of Sphenoid meningioma	1		
Pneumocephalus	2		Extracerebral air, both compound frontal injuries
Early Epilepsy	11		1.2% of head injury admissions
VIII Nerve Deafness	5		2 temporal fractures; 3 NBI
Anosmia	3		2 frontal and 1 occipital fracture
Other cranial nerve lesions	5		3 NBI; 1 parietal; 1 frontal fracture
Hemiparesis/plegia	3		All NBI

Table 3.12 Neurosurgical Events 1976-1977

3.2.6 Mortality:

Altogether sixty-six patients died including one who died in another hospital seventeen days after injury and fifteen days after discharge. There were twenty-three patients who were brought in dead (BID). Post-mortem examination was carried out in fifty-eight patients. In twenty-four patients head injury was not considered to play any part in the patient's death. In seven of these latter cases trauma to the chest and abdomen caused death; six died as a result of coronary occlusion (1 having no P.M); three elderly women were late deaths due to pulmonary emboli in association with pelvic or lower limb fractures; three died following CVA, two of them were late deaths (ten days and twenty-four days) and neither had post-mortems and the other died acutely from a ruptured Berry aneurysm; two patients died late from cardiac failure, neither had a post-mortem and two died late from bronchopneumonia and again neither had a post-mortem. The remaining patient died from a reticulum cell sarcoma. These twenty-four deaths included all eight patients not submitted to post-mortem (none of these eight patients died from traumatic causes.) In the case of the remaining sixteen patients, who were submitted to P.M, none had more than soft tissue injury to the head. Thus there were forty-two head injury deaths, nineteen BIDs and twenty-three dying later. These deaths will now be reported in detail.

a) Incidence, Age and Sex:

Head injury deaths occurred in 0.7% of A&E attenders, while the hospital case-fatality rate was 2.5%, including the four patients who died in the A&E department but excluding BIDs. The overall mortality rate was 16/100,000, 8.8/100,000 if BIDs were excluded. The overall rate for males was 23/100,000 and for females 9.8/100,000. For both sexes together the rate was 4.7/100,000 in children, 19/100,000 in adults aged 15-64 years and 22/100,000 in those over sixty-four years old. However among 15-19 year old males it was 129/100,000. The overall male/female ratio for those dying was 2.2 (1.1 for BIDs and 4.8 for those dying later). The age range

was 6-80 years and the median age twenty-five years. 38% of females were sixty years or older compared with 14% of males. 45% of males were aged 15-19 years and nearly two-thirds were aged 15-29 years, the latter figure for women was less than one sixth. Overall only three patients (7.1%) were children, 76% were aged 15-64 years and 17% over sixty-four years.

b) Predispositions and Associations:

Blood alcohol estimations were either not done (25) or nil (13) in thirty-eight patients. A further three patients had blood alcohol levels of 25, 28 and 30mg% and in the case of the remaining patient, a front-seat passenger, the result was 145 mg%. Thus only about 10% of those dying had definitely been drinking relatively soon before injury. This is an underestimate since among twenty-five patients in whom blood alcohol estimations were omitted, transfusion of large quantities of fluids and blood would have made the results meaningless.

c) Causes:

Road traffic accidents, responsible for 17% of A&E attendances and 36% of head injury admissions, accounted for thirty-three (79%) of the deaths; sixteen were BIDs and seventeen died later. These were made up of 8 pedestrians, 2 cyclists, 14 motorcyclists (13 riders and 1 pillion-passenger), 5 car drivers, 2 front-seat passengers and 2 rear-seat passengers. Twenty-three were male and ten female. More than two-thirds of females killed were pedestrians and of these seven patients, only two were under fifty-five years old, one being twelve years old and the other sixteen years old. The only male pedestrian who died was a six year old boy. No less than fourteen (61%) of the male traffic deaths occurred in motorcyclists, one was sixteen years old, 6 were seventeen years old, 4 were eighteen years old, 1 was twenty years old, 1 was twenty-five years old and 1 was aged seventy-two years. Recent alcohol consumption was evident in two and they had a blood alcohol of 28 and 30 mg% respectively. Five were BIDs. Both

cyclists were young, a girl of ten years of age and a boy aged fifteen years who was dead on arrival at hospital. The girl died after forty-eight hours never regaining consciousness and an unsuspected subdural haematoma was found at post-mortem.

Four of the five car drivers were males and their ages were 24, 25, 58 and 64 years, the only woman was 50 years old. This latter patient and the twenty-five year old male were dead on arrival at hospital. Both front-seat passengers were male and were aged twenty-four and sixty-eight years. The former was BID and had a blood alcohol level of 145 mg%. One male and one female rear-seat passenger, aged twenty-five and fifty years respectively, were killed.

The nine patients not killed in road traffic accidents died as a result of falls (5), industrial accidents (2, falls from height), being hit by a train (1) and falling from a horse (1). One of the five patients who "fell" had committed suicide and might also have been hit by a train. Both patients killed in falls at work were men, aged twenty-four and thirty-nine years. The patient who was definitely hit by a train was a woman, as was the patient who fell from a horse. This latter patient, who was twenty-six years old, developed both acute extradural and acute subdural haematomas, only the former being recognised and treated in life. Of those who fell, four of the five were males aged 45, 50, 57 and 75 years, while the only woman was 43 years old.

d) Temporal Relationships:

Mondays and Fridays were the commonest days for road traffic accidents to occur as a result of which patients subsequently died, nine deaths on each day. Wednesdays were next commonest with seven deaths, followed by Thursdays with six deaths. A half of all pedestrians who died were injured on Mondays and 57% of all motorcyclists who died were injured on Fridays. Three of the five car drivers were injured on Wednesdays and the remaining two on Mondays. No fatal road traffic accidents occurred on Sundays

and only one on a Saturday. Both industrial accidents and the majority of the other non-traffic accidents leading to death occurred mid-week. No major differences were apparent in regard to day of injury and whether death occurred prior to arrival at hospital or subsequently.

Overall deaths were commoner in April and May and again in winter. Nine of the fourteen motorcyclists killed were injured in April and May and three of the eight pedestrians in December. Three out of the five patients dying after falls were injured in June. The onset of winter was associated with a further slight increase in motor-cycle deaths and pedestrian deaths. Again no major differences existed between time to death and month of injury. Death most often occurred in those injured mid-morning, afternoon, early evening and late at night. Sixteen deaths occurred in those injured between 09.00 and 17.00 hours. Four motorcyclists were injured between 21.00 and 22.00 hours and two in the hour up to midnight. Vehicle occupants were more often injured out of office hours, only two out of nine patients being injured between 09.00 and 17.00 hours. Early evening and late at night were equally common times of injury. Deaths due to non-traffic accidents more often occurred between 09.00 and 17.00 hours (two-thirds). Both industrial injuries occurred during the first hour of a work period.

e) Time to Die:

Nineteen patients (45%) died prior to their arrival at hospital and this was commoner in RTA victims (48%) than in other patients (33%) and particularly in pedestrians, three-quarters of whom were BIDs. A further three patients were dead by the end of the first hour after arrival at the A&E department, four more by the end of the first six hours and two more by the end of the first day. Thus within six hours, 62% of patients were dead and within twenty-four hours 67%. Six patients (14%) died during the second twenty-four hours and two (4.8%) during the third day. By the end of the first week, 90% of deaths had occurred. One patient died after eight days, one after ten days, one after twenty days and

another after forty-eight days.

Half of all cyclists, front-seat passengers and rear-seat passengers were dead on arrival at the hospital as were two-fifths of drivers, a third of motorcyclists and three-quarters of pedestrians. The high early mortality among pedestrians was in part at least a reflection of their generally older age. Of the victims of RTA's who were still alive on arrival at hospital, early subsequent death was commoner in motorcyclists and car drivers, a quarter and a third respectively of those alive on arrival dying in the first hour. Both pedestrians, the only remaining cyclist, front-seat passenger and rear-seat passenger survived beyond the first twenty-four hours compared with a third of motorcyclists.

Six patients not involved in RTAs were alive on arrival at hospital. All had suffered falls including two who had fallen from a height at work and one who had fallen from a horse. Both those who fell at work died in the first twelve hours and of the remainder, three died on the second day and one after ten days. The average time to death for non-traffic accident victims, alive on arrival at hospital, was 2.3 days and the median time 1.2 days from the time of arrival at hospital. For the victims of RTAs the average time to death for those alive on arrival at the A&E department was 5.5 days and the median time 1.0 days from the time of arrival at hospital.

f) Post-Mortem Findings:

All post-mortems were macroscopic, thus findings such as white matter shearing injury do not appear in these results.

1. Skull Fractures:

Twenty-nine patients (69%) had skull fractures present at post-mortem, 14 were vault fractures alone, 7 basal fractures alone and 8 were both basal and vault fractures. Two of the vault fractures were depressed. One of the thirteen patients without a fracture at autopsy was considered clinically to have a fractured

base on the basis of bleeding from both ears. All patients with basal fractures and 63% of patients with a fracture of the vault and base were dead on arrival. Conversely only two sevenths of those with vault fractures were dead on arrival and in two of these four patients an extensive compound, comminuted fracture with loss of bone and brain was present. Only 16% of patients dead on arrival had no skull fracture, compared with 43% of patients who died later. Five motorcyclists were dead on arrival; 3 had a basal fracture and 2 had combined fractures of the vault and base. However of nine motorcyclists who died later, 2 had vault fractures only and 7 had no bony injury. Four of eight pedestrians had fractures involving the base and all four were dead on arrival. Among nine vehicle occupants, 4 had no skull fracture, 1 had a fracture of the vault only, 1 had a fracture of the base only and 3 had fractures of the base and vault. Of the non-traffic accidents, vault fractures alone were more common (78%) than fractures of the base (11%) or vault and base (11%). The sixteen patients with skull fractures at autopsy who were BID's and the three patients with fracture at autopsy who died before skull X-ray was possible or in whom a skull X-ray was negative, can be added to the patients with known fracture on skull X-ray. Thus one hundred and eight patients had a skull fracture on X-ray alone or on X-ray and at post-mortem or at post-mortem alone, i.e., 1.9% of all A&E attenders with head injury.

2. Brain Contusions:

Contusions of the brain occurred in twenty-eight patients, 68% of BIDs and 65% of those dying later. Three out of the thirteen BIDs with contusions had no skull fracture and the remainder had either basal (5) basal and vault (4) or vault fractures (1) only, whereas six of the fifteen who died later had no skull fracture, 2 had basal and vault fractures and the remaining 7 had vault fractures. Of all seven patients with a basal fracture, 5 had cerebral contusions and three quarters with base and vault fractures had contusions. Eight of the fourteen with vault fractures had brain contusions and nine of the thirteen with no fracture had

contusions. Three patients (2 vault only and 1 base and vault) had major or complete loss of brain substance and were counted as having no contusions.

All car drivers irrespective of the presence of a fracture and both patients injured in falls at work had contusions compared with 71% of all motorcyclists, 63% of all pedestrians, 60% of those injured in falls and 50% of front-seat and rear-seat passengers. Neither of the cyclists had cerebral contusions, although one had complete loss of brain substance. The latter type of injury also occurred in an elderly woman hit by a train and in a motorcyclist.

3. Brain Lacerations:

Laceration of the brain occurred in twelve patients (29%), three of whom had extensive injury with loss of all or most of the brain. Of the remaining nine patients, 2 had lacerations over the cerebral convexity, 2 of the undersurface, 1 had a cerebellar laceration, 1 had a pontine laceration, 1 had a laceration of the medulla oblongata, 1 a laceration of the brain-stem and 1 lacerations of the brain-stem and cerebellum. Three quarters of the patients had skull fractures - 5 vault, 2 base and 2 vault and base. Excluding the patients with severe loss of brain substance, lacerations occurred in 40% of those injured in falls, 50% of rear-seat passengers, a quarter of pedestrians and 23% of motorcyclists. One half of the patients with lacerations died after admission.

4. Cerebral Oedema:

Only seven patients (17%) had cerebral oedema, five were less than twenty years old and the oldest was forty-two years old. None of these patients were dead on arrival. Three had no skull fracture and one of these three patients had, in addition, a brain-stem laceration, while another had a cerebral contusion. All four patients with skull fractures had vault fractures, in addition one had an acute subdural haematoma, another had a cerebellar

laceration and contusions were present in the remaining two patients. Three of the seven were motorcyclists, 1 was a pedestrian, 1 a cyclist, 1 a rear-seat passenger and the other had fallen.

5. Intracranial Haematoma:

Post-traumatic intracranial haematomas were found in four patients, all of whom had vault fractures. In one patient an acute subdural haematoma, unsuspected in life, was found, the patient having died fifty-one hours after admission. An acute subdural haematoma was also found in a patient who had an acute extradural haematoma evacuated during life and who died twenty-six hours after admission. An intracerebral haematoma was discovered in a man who had undergone emergency Burr hole exploration for a suspected subdural haematoma, no haematoma being found at operation. Finally, a man, who had evacuation of an acute subdural haematoma and who died thirty hours after admission, had some residual subdural blood at post-mortem associated with a cerebral laceration. The latter patient also had a pontine haemorrhage thought to be non-traumatic and responsible for the sequence of fall - head injury with skull fracture - acute subdural haematoma. Two of the first three patients had cerebral contusions as well and the third had cerebral oedema. A haematoma of the falx cerebri was present in another patient unconscious from the time of injury who also had a basal and parietal contusion ipsilateral to a right temporal fracture and a contralateral temporal contusion.

The foregoing autopsy findings and their relationship to the time of death and the presence and type of skull fracture are summarised in Tables 3.13-3.16.

6. Spinal Injuries:

These were uncommon among the forty-two patients who died as a result of head injury, only six patients having such an injury. Five of these were BIDs and the remaining patient died nine

TYPE OF PATIENT	SKULL FRACTURE				
	NONE	VAULT	BASE	VAULT & BASE	TOTAL
ALL PATIENTS	13	14	7	8	42
BID	3	4	7	5	19
WITH CONTUSIONS	9	8	5	6	28
WITH LACERATIONS	3	5	2	2	12
WITH OEDEMA	3	4	0	0	7

Table 3.13 Gross pathological findings related to skull fracture.

TIME TO DIE	SKULL FRACTURE				
	NONE	VAULT	BASE	VAULT & BASE	TOTAL
BID	3	1	5	4	13
0 - 6 HOURS	2	2		1	5
6 - 24 HOURS	1	1			2
24 - 48 HOURS	1	2			3
48 - 72 HOURS		1			1
MORE THAN 3 DAYS	2	1		1	4
TOTAL	9	8	5	6	28

Table 3.14 Relationship between time to death and the presence and type of skull fracture in patients with brain contusions.

TIME TO DIE	SKULL FRACTURE				
	NONE	VAULT	BASE	VAULT & BASE	TOTAL
BID		2	2	2	6
0 - 6 HOURS	1	1			2
24 - 48 HOURS		2			2
72 - 96 HOURS	1				1
20 DAYS	1				1
TOTAL	3	5	2	2	12

Table 3.15 Relationship between time to death and the presence and type of skull fracture in patients with brain lacerations.

TIME TO DIE	SKULL FRACTURE				
	NONE	VAULT	BASE	VAULT & BASE	TOTAL
BID					
0 - 6 HOURS	2				2
24 - 48 HOURS		2			2
48 - 72 HOURS		2			2
72 - 96 HOURS	1				1
TOTAL	3	4	0	0	7

Table 3.16 Relationship between time to death and the presence and type of skull fracture in patients with cerebral oedema.

hours after admission. Three of the patients were elderly women, all pedestrians and all BIDs. Two of the men were injured in falls (1 at work) and the other was a motor-cycle rider. In one patient, an eighty year old pedestrian, a dislocation of T3 on T4 was present while the five remaining patients all had spinal fractures: 1 upper cervical fracture with laceration of the brain-stem and cerebellum (motorcyclist) and 4 patients with fractures of the thoracic spine. The latter four patients and the patient with a thoracic dislocation all had severe chest injuries and in addition two had severe and two had moderate abdominal injuries.

Two of the twenty-four patients who died from causes other than head injury had spinal injuries. Both were elderly pedestrians, an eighty year old man and an eighty-one year old woman. The woman, who had a fracture of the upper lumbar spine and abdominal injuries, died fourteen hours after admission. The man, who had a fracture of the lower cervical spine, was dead on arrival and had in addition a ruptured arch of aorta, bilateral rib fractures, a fractured pelvis and fractures of both tibiae and fibulae.

7. Chest Injuries:

Fifteen of the nineteen BIDs had chest injuries and apart from one patient hit by a train and one patient killed in a fall, all were the victims of road traffic accidents. Pulmonary contusions were present in six patients, bilateral in half and accompanied by rib fractures in two (1 unilateral and 1 bilateral). Three patients had bilateral and one patient had right sided pulmonary lacerations, all had multiple rib fractures, unilateral in one patient with bilateral lacerations and bilateral otherwise. None of these four patients had pulmonary contusions, one had bilateral and one a left sided haemothorax. Altogether eight of the fifteen patients had haemothoraces, bilateral in half, right sided in two and left sided in 2. Only one patient had a fractured sternum, associated with bilateral fractures of the first two ribs, contusion of the anterior mediastinum and haemothorax. Three

patients had fractures and one a dislocation of the thoracic spine, while a further patient had a fracture of the upper cervical spine in association with bilateral pulmonary contusion. Four patients (2 pedestrians, 1 motorcyclist and 1 car driver) had a rupture of the aorta, the two pedestrians also having fractures of the thoracic spine and one of them a ruptured right hemidiaphragm as well. The patient struck by a train had an extensively lacerated heart.

Nine of the twenty-three patients who died later had chest injuries. Only two were not injured in traffic accidents, both being injured in falls. Two patients had bilateral and one patient unilateral pulmonary contusions. In one case of bilateral contusion, no rib fracture was present, although there was a unilateral haemopneumothorax. The single case with unilateral pulmonary contusion was associated with an ipsilateral flail chest, pulmonary laceration and haemothorax. In addition to the above two patients, four other patients had haemothoraces, one of which was bilateral and accompanied by a fracture of the sternum and of the thoracic spine. One left sided haemothorax was associated with a rupture of the aorta as well as multiple bilateral rib fractures and this patient, a front-seat passenger, survived for thirty-two hours. A traumatic aneurysm of the arch and descending aorta was found at post-mortem in a rear-seat passenger who died nearly four days after injury. In total, three patients had fractures of the sternum and five had fractures of the ribs.

In patients dying without evidence of skull fracture or intracranial injury, six had chest injuries similar to the above and including one elderly patient with a fracture of the lower cervical spine and a ruptured aorta. One car driver had a laceration of the right ventricle.

8. Abdominal Injuries:

Among patients dying before arrival at hospital, abdominal injury was less common than chest injury. Only eleven patients had abdominal injury, six of these being lacerated spleens, including

all four patients with a lacerated liver and three of the four patients with renal lacerations, as well as the only patient with a perforated bladder. Five of the patients with abdominal injury had renal or peri-renal contusions, one also having a lacerated spleen. The patient with a perforated bladder was an elderly pedestrian who has already been mentioned above and who had a dislocation of the thoracic spine. Of the eleven patients, 6 were pedestrians, 2 were vehicle occupants, 2 motorcyclists and 1 patient was hit by a train. Abdominal injuries were also less common than chest injuries in patients who died after arrival at hospital. Only three patients having such injuries, one motorcyclist and both patients injured in falls at work. Laceration of the spleen was present in two, one also having a hepatic laceration and the third patient had a peri-renal haematoma.

One of the patients from the non-head-injured group, who died from pulmonary embolism sixteen days after admission, had repair of a jejunal perforation and splenectomy shortly after admission. In addition, a motor-cycle rider from the same group had extensive lacerations of the liver, spleen and right kidney and died thirty-eight minutes after arrival at the A&E department. A sixteen year old front-seat passenger died forty minutes after admission and had extensive tears of the spleen and left kidney. Finally an eighty-one year old pedestrian with a fracture of the upper lumbar spine, died fourteen hours after admission and had bilateral renal contusions and peri-renal bleeding.

9. Fractures:

Pelvic fractures occurred in four of the nineteen patients who were dead on arrival at hospital. Two of these were pedestrians, one was a car driver and one patient was hit by a train. One of the pedestrians had a dislocation of her right sacro-iliac joint and pubis. Among those with head injury dying later, one pedestrian and two motor-cycle riders had pelvic fractures. Four of the twenty-four patients whose deaths were unrelated to head injury had pelvic fractures, all were elderly

pedestrians and the only man also had a ruptured aorta, bilateral rib fractures, a fracture of the lower cervical spine and bilateral fractures of the lower legs. One of the remaining three women died from a pulmonary embolism nine days after admission because of a fractured ilium. The remaining two women died one and a half hours and fourteen hours after admission.

Fractures of the upper limbs or shoulder girdle occurred in six patients dying before arrival at hospital. In one patient these fractures, although unilateral, involved more than one anatomical site. Only one of these six patients had bilateral fractures and multiple sites were involved, and this patient had been hit by a train. Four of the remaining five patients were injured in road traffic accidents and the other in a fall. Twenty-three patients in whom head injury was related to death died after admission to hospital and in six of these fractures of the upper limb or shoulder girdle were present. In one of these injury resulted from a fall, the remainder were injured in road traffic accidents. A front-seat passenger, who also suffered a ruptured aorta, had bilateral upper limb and rib fractures while in the other five patients the fractures were unilateral. Upper limb fractures occurred in three patients who died but not as a result of head injury. In two patients the injury was unilateral, although involving more than one site in one of them. In the third patient, a car driver, bilateral compound, comminuted forearm fractures were present, as well as multiple bilateral rib fractures, pulmonary lacerations and a laceration of the right ventricle.

Lower limb fractures occurred in seven BIDs and predictably were more common in pedestrians (5 patients). The other two patients were a motorcyclist and the patient hit by a train. In the case of the five pedestrians, 2 had unilateral fractures, 2 had bilateral fractures and 1 had unilateral fractures at more than one site. The patient struck by a train had bilateral fractures involving many sites and the motorcyclist had a femoral fracture alone. Only three patients who died after arrival at hospital had lower limb fractures, 2 motorcyclists and 1 patient injured in a

fall at work. In each case the fractures were unilateral. Among those patients dying other than from head injury, two pedestrians, a car driver and a patient injured in a fall had lower limb fractures. In the case of one of the pedestrians the injuries were bilateral, this patient also had a ruptured aorta, fractured lower cervical spine, a fractured pelvis and bilateral rib fractures.

One fracture was unique to motorcyclists. One of these, who died thirty-two minutes after arrival at the A&E department, had a fracture of the hyoid bone as well as fractures of the larynx. The second patient also died after admission and also had a fractured hyoid bone. In addition, the former patient had multiple facial fractures, a fracture of the distal femur and a cerebral contusion, while the latter had a laceration of the lower medulla oblongata and generalised cerebral contusions.

Fracture of the facial bones occurred in four patients, one being the motorcyclist mentioned in the preceding paragraph. Another was a rear-seat passenger, who sustained compound fractures of the maxillae and mandibles, subsequent treatment included ligation of the common and external carotid arteries. This patient died on the fourth day and at post-mortem was found to have a brain-stem laceration as well as a traumatic aneurysm of the arch and descending aorta. Fracture of the mandible also occurred in a young woman who was a front-seat passenger and also sustained extensive chest and abdominal injuries. The fourth patient, a pedestrian, had bilateral compound fractures of the mandible as well as multiple lower limb fractures and fractures of all ribs bilaterally.

10. Combinations Of Injury:

Considering all sixty-six deaths, various combinations of injury of the type and severity already described, occurred in forty-nine patients. Among the remaining patients, thirteen died from purely medical causes. Two late deaths were due to pulmonary embolus in patients with pelvic fractures only, one patient died

from a pulmonary embolus developing as a complication after injury causing jejunal perforation and a lower limb fracture, and finally one elderly patient died from cardiac failure thirty-three days after presenting with a pertrochanteric fracture of the femur and a minor head injury associated with brief unconsciousness. The combinations of injuries present in the group of forty-nine patients dying as a result of trauma are shown in tables 3.17, 3.18 and 3.19. Certain patterns are apparent. For example, of sixteen motorcyclists, ten had chest injuries, four in combination with head injury and the remainder in combination with abdominal injuries or fractures or both. The quartet of head + chest + abdominal injuries + fractures occurred most often in pedestrians, four of eleven pedestrians having this set of injuries, compared with one of sixteen motorcyclists, one of 6 car drivers and one of seven injured in falls. Fractures in association with one or more of the above types of injury occurred in eight of eleven pedestrians, but only three of sixteen motorcyclists, two of six car drivers and one of seven injured in falls. Fifteen patients had an abdominal injury alone or in combination and seven of these were pedestrians, three were motorcyclists, and car drivers, front-seat passengers and rear-seat passengers accounted for one each, the remaining two being the patient hit by a train and a patient who fell at work. Head injury alone occurred in fourteen patients, 4 falls, 4 motorcyclists, 2 cyclists, 1 car driver, 1 front-seat passenger, 1 patient who fell from a horse and only 1 pedestrian.

11. Injury Severity Scoring:

This system allows a numerical comparison of different combinations of injury. The Injury Severity Scores (ISS) for the forty-nine patients dying as a result of trauma and derived from their post-mortem reports are shown in Figure 3.22. For thirty-two patients injured in road traffic accidents the mean ISS was 41.8 and for those injured in other accidents 32.3. For all forty-two head injury deaths the mean ISS was 38.8 (43.9 for BIDs and 34.5 for those dying later). The contribution to each score made by the head injury averaged 23.6 for BIDs and 21.4 for those dying later. Thus

COMBINATIONS OF INJURY	TYPE OF PATIENT	TOTAL
HEAD ONLY	1 FRONT-SEAT PASSENGER 1 FALL 1 CYCLIST	3
HEAD & CHEST	4 MOTORCYCLISTS 1 FALL 1 DRIVER	6
HEAD CHEST & ABDOMEN	1 REAR-SEAT PASSENGER 1 PEDESTRIAN	2
HEAD CHEST ABDOMEN & FRACTURE	4 PEDESTRIANS 1 MOTORCYCLIST 1 DRIVER 1 HIT BY TRAIN	7
HEAD ABDOMEN & FRACTURE	1 PEDESTRIAN	1

Table 3.17 Relationship between cause of injury and combinations of injury in nineteen patients brought in dead.

COMBINATIONS OF INJURY	TYPE OF PATIENT	TOTAL
HEAD ONLY	3 FALLS 4 MOTORCYCLISTS 1 CYCLIST 1 DRIVER 1 PEDESTRIAN 1 FALL FROM A HORSE	11
HEAD & CHEST	2 DRIVERS 2 MOTORCYCLISTS 1 FALL 1 FRONT-SEAT PASSENGER 1 REAR-SEAT PASSENGER	7
HEAD CHEST & ABDOMEN	1 MOTORCYCLIST	1
HEAD CHEST ABDOMEN & FRACTURE	1 FALL	1
HEAD & FRACTURE	2 MOTORCYCLISTS 1 PEDESTRIAN	3

Table 3.18 Relationship between cause of injury and combinations of injury in twenty-three patients dying after arrival at hospital.

additional injuries were more severe, more extensive or both in patients dying before arrival at hospital than in those dying later, as one would expect. The mean ISS for non-head injury deaths due to trauma was 37.3. None of the Injury Severity Scores quoted above have been age-corrected. The mean ISS for all pedestrians was 36.8,

COMBINATIONS OF INJURY	TYPE OF PATIENT	TOTAL
CHEST	1 MOTORCYCLIST	1
ABDOMEN	1 PEDESTRIAN	1
CHEST & ABDOMEN	1 MOTORCYCLIST	1
CHEST ABDOMEN & FRACTURE	1 FRONT-SEAT PASSENGER	1
CHEST & FRACTURE	2 PEDESTRIANS 1 DRIVER	3

Table 3.19 Relationship between cause of injury and combinations of injury in seven patients dying from trauma but not because of head injury.

for all motorcyclists was 44.0 and for vehicle occupants 36.2.

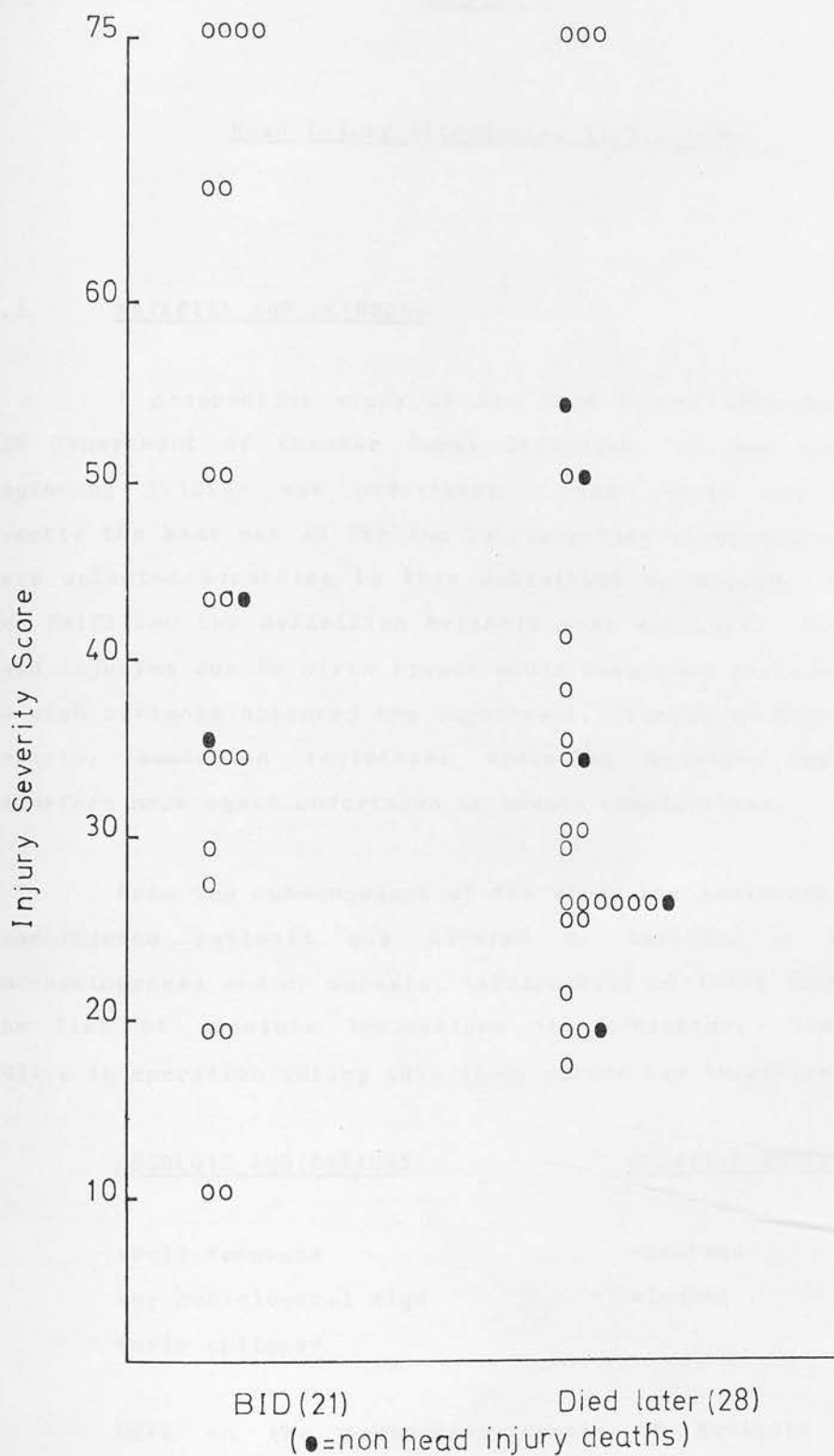


Figure 3.22 Distribution of Injury Scores

CHAPTER 4

Head Injury Attendances 1979 - 1980

4.1 MATERIAL AND METHODS:

A prospective study of all head injury attendances at the A&E Department of Chester Royal Infirmary for the twelve months beginning 1.12.79 was undertaken. Head injury was defined in exactly the same way as for the retrospective study and all patients were selected according to this definition by myself. No patients who fulfilled the definition criteria were excluded. Patients with head injuries due to birth trauma would have been excluded, however, no such patients attended the department. Checks on all post-mortem reports, admission registers, operating theatre registers and transfers were again undertaken to ensure completeness.

From the commencement of the study the admission policy for head-injured patients was altered by omitting a history of unconsciousness and/or amnesia, irrespective of their duration, from the list of absolute indications for admission. The admission policy in operation during this study period was therefore:-

ABSOLUTE INDICATIONS

skull fracture
any neurological sign
early epilepsy

RELATIVE INDICATIONS

symptoms
alcohol

Data on the presenting sample of patients was again transferred to a computer input form (Figure 4.1) only slightly modified from that used for the retrospective study (Figure 3.1). The same criticism applied in regard to the estimation of X-ray usage as in the initial study. Data was recorded in the same way as

] 01

Patient's Number	Years	Months	Sex
<input type="text"/>	<input type="text"/>	<input type="text"/>	M <input type="checkbox"/> F <input type="checkbox"/>
Date of Admission	Time of Admission	Predisposition	
<input type="text"/>	<input type="text"/>	Nil GP CVS EPYGM ₄ H ₅ FS Other <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	

] 02

Mechanism	KTA														
	Ass	Intd	Spec	Fall	Fall	Pod	Cyc	M ₁	M ₂	C ₁	C ₂	C ₃	N ₁	Other	Not Rec
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E
Belt/Helmet	KO'd		Amnesic		Vomited		CNS Signs								
Yes No Not Rec	Yes No Not Rec	Yes No Not Rec	Yes No Not Rec	Yes No Not Rec	Yes No Not Rec	Yes No Not Rec	Yes No Not Rec								
0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2	0 1 2								

X-Ray

No	Sk	Face	Nose	Mand	C ₁	UL	Chest	Th	Sp	L-S	Revis	L-L	Abdo
0	1	2	3	4	5	6	7	8	9	A	B	C	

] 03

Fracture

No	Sk	Face	Nose	Mand	C ₁	UL	Chest	Th	Sp	L-S	Revis	L-L	Abdo
0	1	2	3	4	5	6	7	8	9	A	B	C	

] 04

Treatment

Nil	MI	S	Att	Stn	IVT	Ext	Blood	Ch	L	PL	ETT	Lava	G	A	Mann	Surg	Other
0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F		

] 05

Admitted

No	TOD	RC1	RC2	Read	ITU	24	48	72	1/52	10/7	2/52	3/52	1/12	6/52	2/12	3/12	4/12	TRF
0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	G	H	I

Yes	No	Not Rec
0	1	2

Prev. Adm. Criterion

Mortality

No	BID	24	48	72	1/52	10/7	2/52	3/52	1/12	6/52	2/12	3/12	4/12
0	1	2	3	4	5	6	7	8	9	A	B	C	D

Reason

X 50	? #	#	Signs	Fit	Surg	Ortho	Eye	ENT	FM	Med	Ger.	Other	N/A		
0			3	4	5	6	7	8	9	A	B	C	D	E	F

Surname

Address

Figure 4.1 Data Input sheet 1979-80

in the retrospective study with regard to age, day, date etc.

Patients who would have been admitted according to the orthodox policy, but who were not admitted as a result of the more selective policy, were identified separately. Subsequently their GPs were contacted and asked whether the patient had died or suffered any problem or complication which could be attributed to their head injury. If the answer to any question was yes further details were requested. In a small number of patients for whom no GP could be identified the patients were contacted directly by telephone.

Notable changes in the catchment area during the study period included a strike followed by several thousand redundancies at the British Steel Plant at Shotton in Clwyd. Redundancies also occurred at some of the light industrial plants in Ellesmere Port.

Independently of this study and as part of the teaching programme within the A&E Department a discussion regarding X-ray utilisation was held approximately two months after the start of the prospective study. As a direct result of this meeting X-ray usage declined, particularly in regard to requests for X-ray of the skull, nasal bones, ribs and digits. Although the decline in such requests was not sustained, the previous levels of usage were not reached. This applied particularly to X-ray of the nasal bones, very few patients ever again having this investigation carried out. X-ray usage was also curtailed as a result of a strike by radiographers which occurred about half way through the course of the study.

4.2 RESULTS:

4.2.1 Catchment Population:

The mid-1980 population of Chester district was 181,800 according to figures published by the Mersey Regional Health Authority (427). The total catchment population for the area served by the A&E Department at Chester Royal Infirmary during the study period was estimated at 262,500. The age and sex distribution of this population is shown in Figure 4.2. The age-distribution of the catchment population is significantly different from the mid-1980 population of England and Wales (114) (chi-squared = 1186.51, D.O.F = 15, p much less than 0.0005). This difference was due to both an over-representation of young people (5-19 year olds) and an under-representation of elderly people (65 years and over) in the catchment population. Thus 10-14 year olds were over-represented by 11% and 5-19 year olds by 6.2% whereas those over seventy-four years old were under-represented by 15% and all those over sixty-four years by 13%. The male/female ratio of the catchment population (0.944) was not significantly different to that of England and Wales (0.952) (chi-squared = 3.56, p greater than 0.05).

4.2.2 Total Accident and Emergency Attendances:

The annual totals of new A&E attendances for the years 1970 to 1980 inclusive, as well as the monthly sub-totals are shown in Table 4.1. An average increase of 1109 patients per year occurred during this period. However there was a small decrease in new attendances between 1974 and 1975 and a larger one between 1979 and 1980. Attendances were consistently higher during the summer months. During the period of the study there were 36,669 new attenders. The age and sex distribution of these new patients based on a 10% sample of new patients is shown in Figure 4.3. Of the sampled population 2,323 were male and 1,303 were female, a male/female ratio of 1.8. The same shift towards the younger age groups that was evident in the retrospective study was again apparent, more than half of all new patients were less than

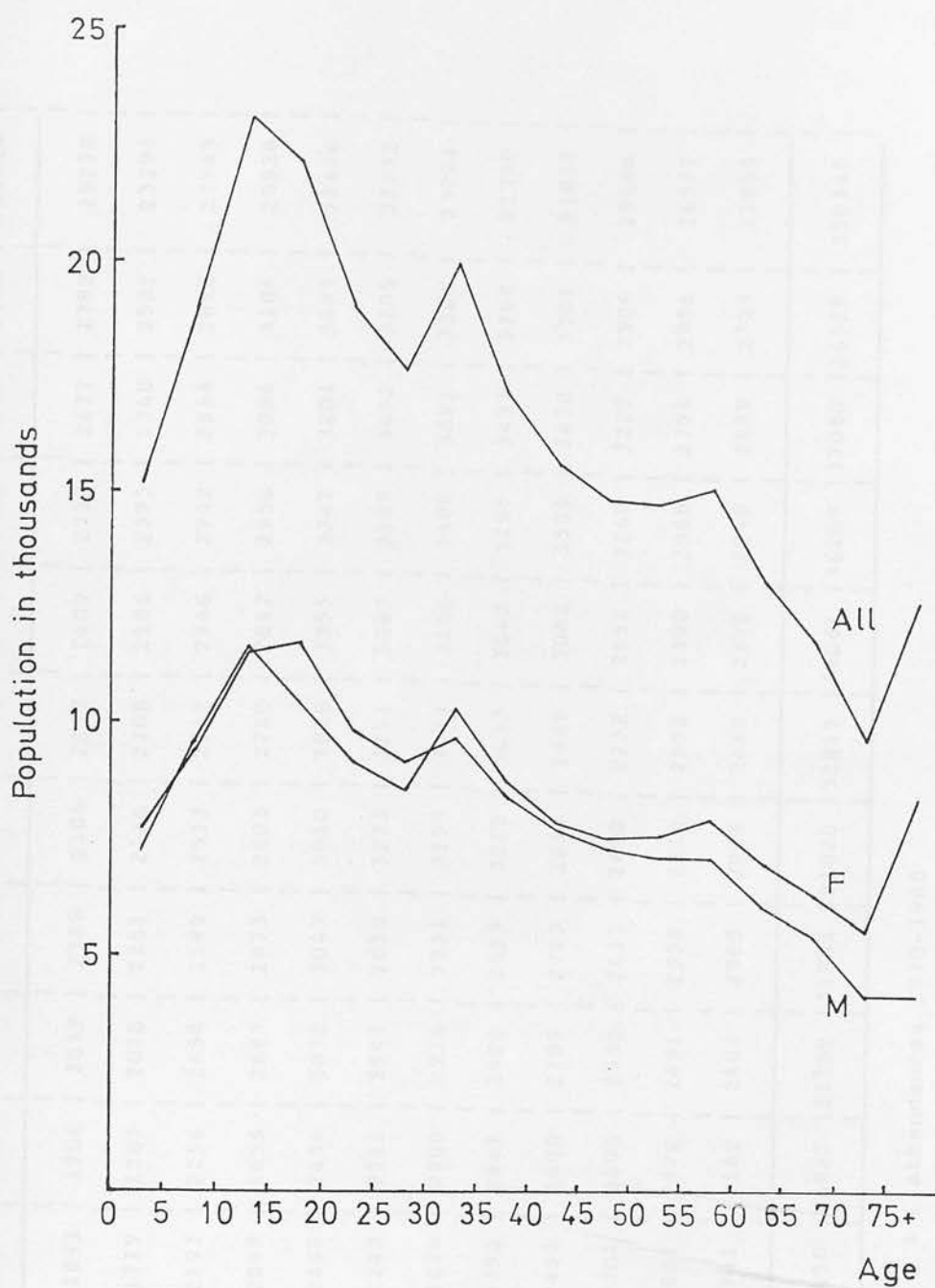


Figure 4.2 Age-distribution of catchment population

MONTH	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	TOTALS
JANUARY	1850	1891	1906	2019	2388	2304	2297	2409	2737	2677	2792	25270
FEBRUARY	1688	1779	1783	2070	2241	2124	2108	2186	2393	2340	2582	23294
MARCH	1826	2193	2256	2654	2599	2533	2512	2746	2942	2858	2826	27945
APRIL	2045	2249	1656	2695	2873	2603	2760	2817	2956	3086	3184	28924
MAY	2376	2468	2434	2872	3047	3010	3026	3355	3342	3201	3495	32626
JUNE	2543	2243	2312	2947	2830	3273	3251	3087	3189	3452	3205	32332
JULY	2345	2674	2700	2916	2931	3153	3411	3156	3480	3692	3263	33721
AUGUST	2370	2390	2441	2908	2853	3212	3033	3043	3295	3437	3368	32350
SEPTEMBER	2493	2451	2600	2785	2723	2814	2669	3042	3505	3430	3301	31813
OCTOBER	2095	2304	2400	2539	2625	2600	2732	2952	3262	3227	2908	29644
NOVEMBER	1949	1867	2172	2451	2338	2134	2556	2590	2868	2791	2856	26572
DECEMBER	1861	1941	2182	2403	2383	2068	2460	2678	2240	2889	2749	25854
TOTALS	25441	26450	26842	31259	31831	31828	32815	34061	36209	37080	36529	350345

Table 4.1 Total new A & E attendances 1970-1980

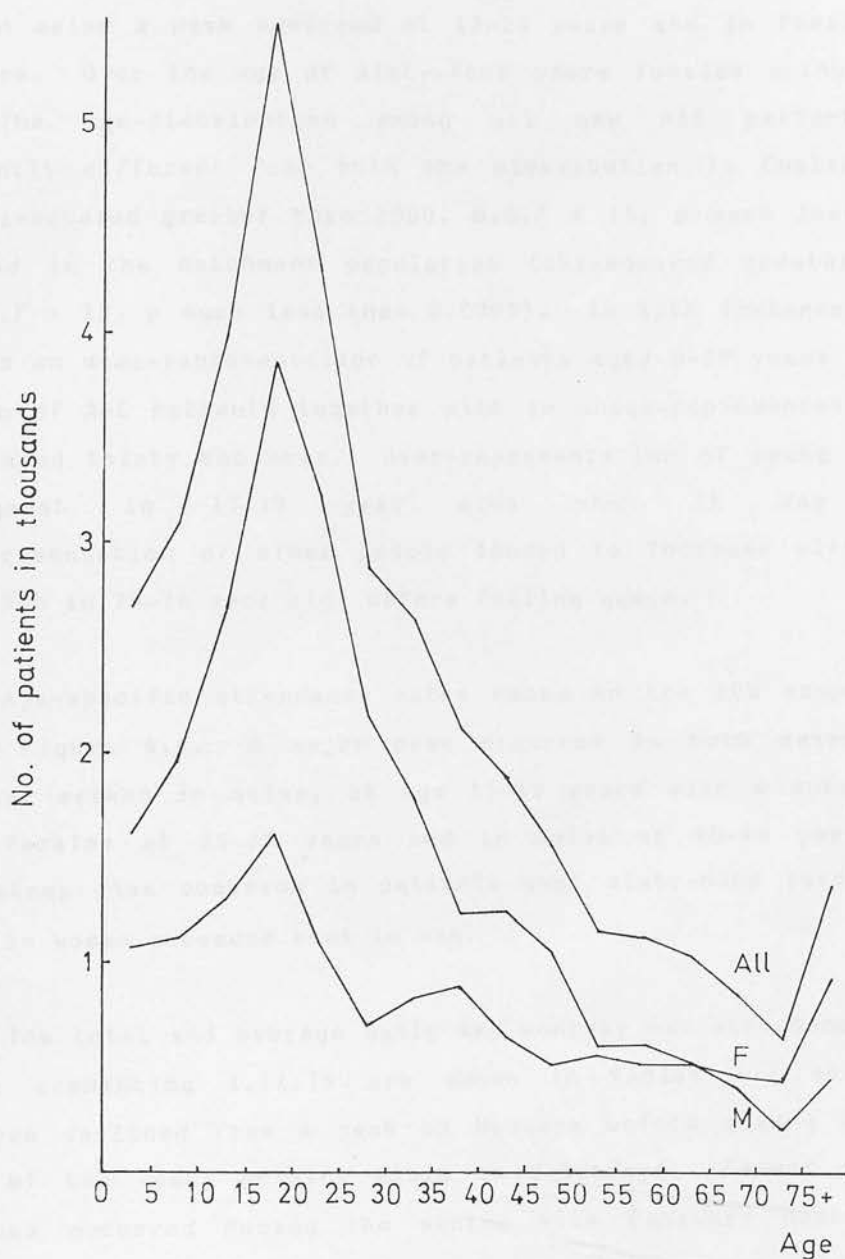


Figure 4.3 Estimated age-distribution of new A&E patients

twenty-five years old and about one quarter were less than fifteen years. In males a peak occurred at 15-24 years and in females at 10-19 years. Over the age of sixty-four years females outnumbered males. The age-distribution among all new A&E patients is significantly different from both the distribution in England and Wales (chi-squared greater than 2000, D.O.F = 15, p much less than 0.005) and in the catchment population (chi-squared greater than 2000, D.O.F = 15, p much less than 0.0005). In both instances this was due to an over-representation of patients aged 0-29 years in the population of A&E patients together with an under-representation of patients aged thirty and over. Over-representation of young people was highest in 15-19 year olds when it was 75%. Under-representation of older people tended to increase with age, reaching 53% in 70-74 year olds before falling again.

Age-specific attendance rates based on the 10% sample are shown in Figure 4.4. A major peak occurred in both sexes, but particularly marked in males, at age 15-19 years with a subsidiary peak in females at 35-39 years and in males at 40-44 years. A further steep rise occurred in patients over sixty-nine years when the rate in women exceeded that in men.

The total and average daily and monthly new attendances for the year commencing 1.12.79 are shown in tables 4.2 and 4.3. Attendances declined from a peak on Mondays before rising towards the end of the week, peaking again on Saturdays. Fewest monthly attendances occurred during the winter with February having the least number and the lowest daily average. Attendances during the summer months were higher, highest in May, and were followed by a further rise in late summer and early autumn. The increase in attendances during the summer months was largely due to an increase in visits by young people, particularly children. Attendances by children during the summer were double those during the winter.

The daily distribution of new A&E patients was significantly different to a distribution in which equal numbers attended on each day of the week (chi-squared = 32.99, D.O.F = 6, p

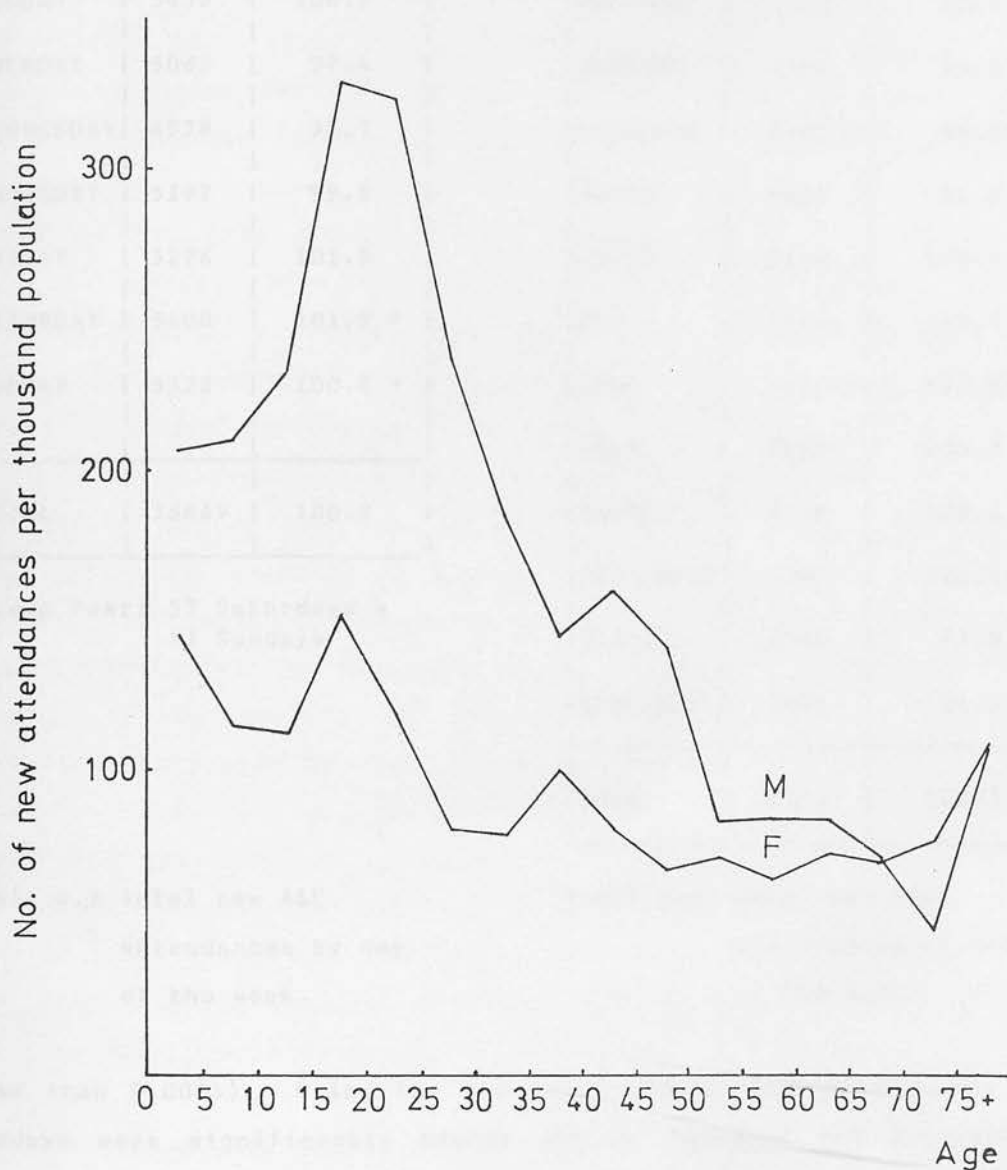


Figure 4.4 Estimated age-specific attendance rates of new A & E patients

DAY	TOTAL	DAILY AVERAGE
MONDAY	5435	104.5
TUESDAY	5066	97.4
WEDNESDAY	4978	95.7
THURSDAY	5192	99.8
FRIDAY	5276	101.5
SATURDAY	5400	101.9 *
SUNDAY	5322	100.4 *
TOTAL	36669	100.2

* Leap Year: 53 Saturdays +
53 Sundays

MONTH	TOTAL	DAILY AVERAGE
DECEMBER	2889	93.2
JANUARY	2792	90.1
FEBRUARY	2582	89.0*
MARCH	2826	91.2
APRIL	3184	106.1
MAY	3495	112.7
JUNE	3205	106.8
JULY	3263	105.3
AUGUST	3368	108.6
SEPTEMBER	3301	110.0
OCTOBER	2908	93.8
NOVEMBER	2856	95.2
TOTAL	36669	100.2

Table 4.2 Total new A&E
attendances by day
of the week

Table 4.3 Total new A&E
attendances by month
of the year

less than 0.0005). Using the "zI test" showed that attendances on Mondays were significantly higher and on Tuesdays and Wednesdays significantly lower than expected if equal numbers were assumed to attend every day. Although attendances rose at the weekends, the magnitude of this rise did not produce significantly higher numbers. Again using the "zI test", attendances in the months April, May, June, July, August and September were significantly higher than expected if equal numbers were assumed to attend on each day of the year. Likewise, attendances for the months of December, January, February, March, October and November were significantly less than expected.

Figure 4.5 shows the hourly distribution of new patients. One main peak and several subsidiary peaks were evident, each succeeding peak being of lower magnitude than the preceding one. The highest peak occurred at 11.00-12.00 hours with lesser peaks at 14.00-15.00, 16.00-17.00 and 18.00-19.00 hours. No late night peak occurred although the rate of decline from the early evening peak was slowed between 23.00 and 01.00 hours. 41% of all new patients attended the department between 09.00 and 17.00 hours on weekdays. A further 34% attended between 17.00 hours on Friday evening and 09.00 on Monday. When the hourly distribution was considered for each day separately, certain patterns emerged. On all weekdays the highest peak occurred in the morning although it was more often earlier than for the overall distribution, occurring at 09.00-10.00 or 10.00-11.00 hours. The early afternoon peak always occurred at 14.00-15.00 during the week while the evening peak occurred at 18.00-19.00 or 19.00-20.00 hours. A late afternoon peak only occurred on Tuesdays, Wednesdays and Fridays when it was at 16.00-17.00 hours. On Thursdays and Fridays only a late night peak occurred at 23.00-24.00. At weekends the major peak occurred later than during the week at 11.00-12.00 and was also broader. No early afternoon peak occurred, instead a higher and more sustained peak occurred a little later at 15.00-16.00 hours. Also in contrast to the position during the week this afternoon peak was higher than the morning peak. Moreover it extended into the evening, incorporating the early evening peak in its tail. Finally a late night peak occurred at 23.00-24.00 hours.

Discernible patterns also became evident when the hourly distribution was considered for each month separately. There was a tendency for the morning peak to occur earlier during the winter (09.00-10.00) than during the summer (11.00-12.00), whereas the early afternoon peak remained constant at 14.00-15.00 hours. Likewise, the evening peak tended to occur earlier in the winter months (18.00-19.00) and later in the summer (19.00-20.00). Also in October, December, January and February a late night peak occurred at 23.00-24.00 hours. During the warmer months the early evening peak was a little higher than the afternoon peak. Otherwise the

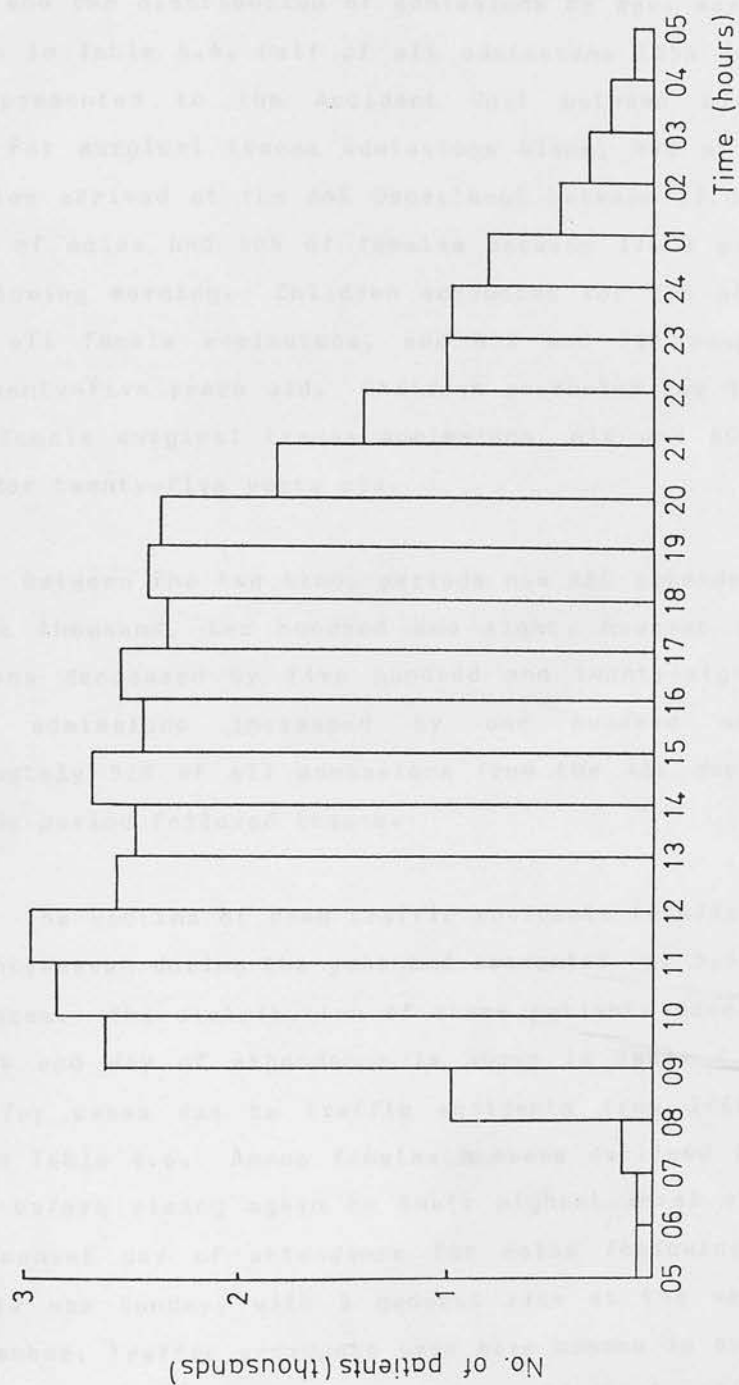


Figure 4.5 Hourly distribution of all new A&E patients

stepwise fall with each succeeding peak was maintained.

During the twelve months of the study period, two thousand, four hundred and seventy-nine patients (6.8%) were admitted directly from the Accident Unit. The male/female ratio for these admissions was 1.4 and the distribution of admissions by age, sex and specialty is shown in Table 4.4. Half of all admissions (55% females and 46% males) presented to the Accident Unit between 09.00 and 17.00 hours. For surgical trauma admissions alone, 40% of males and 36% of females arrived at the A&E Department between 17.00 and midnight and 60% of males and 50% of females between 17.00 and 09.00 hours the following morning. Children accounted for 23% of all male and 19% of all female admissions, and 43% and 34% respectively were under twenty-five years old. Children accounted for 32% of male and 41% of female surgical trauma admissions, 61% and 60% respectively were under twenty-five years old.

Between the two study periods new A&E attendances increased by three thousand, two hundred and eight, however surgical trauma admissions decreased by five hundred and twenty-eight and general medical admissions increased by one hundred and sixty-one. Approximately 52% of all admissions from the A&E department during the study period followed trauma.

The victims of road traffic accidents totalled two thousand and twenty-seven during the year and accounted for 5.5% of new A & E attendances. The distribution of these patients according to their age, sex and day of attendance is shown in Table 4.5. The annual totals for cases due to traffic accidents from 1969 to 1981 are shown in Table 4.6. Among females numbers declined from a peak on Mondays before rising again to their highest level at the weekend. The commonest day of attendance for males following road traffic accidents was Sunday, with a general rise at the weekend. Except for December, traffic accidents were more common in summer, reaching their peak in August. Two-fifths of accidents in children occurred on Saturdays and Sundays, usually between 11.00 and 19.00 hours. 57% of all accidents (61% males and 47% females) involved patients

SPECIALTY	0-9		10-19		20-29		30-39		40-49		50-59		60-69		70-79		80+		TOTAL	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
GENERAL SURGERY	14	10	27	20	34	16	16	6	12	8	19	8	14	5	12	5	4	3	152	81
SURGICAL TRAUMA	83	59	113	31	80	24	33	9	38	19	26	8	20	10	9	15	3	8	405	183
ORTHOPAEDIC TRAUMA	29	18	81	16	53	15	28	10	27	13	20	19	22	31	16	76	5	86	281	284
GENERAL ORTHOPAEDICS	9	4	4	3	2	2	3	1	1	1	3	4	2	1	2	1			26	17
PAEDIATRICS	73	53	4	7															77	60
MEDICINE			27	29	39	13	42	23	51	27	80	35	80	40	45	20	3	2	367	189
GERIATRICS													1	3	31	38	17	51	49	92
PSYCHIATRY			1	1	6	5	4	3	6	2	2	2	1	2	2	0			22	15
ENT	6	1	3	2	2	2	0	1	3	3	6	6	7	7	5	6	2	4	34	32
EYES	4	0	16	7	10	2	3	2	8	0	4	3	4	6			1	1	50	21
GYNAECOLOGY				8		19		5		1		1		1					0	35
FACIO-MAXILLARY					1	2													1	2
OBSTETRICS				1		2		1											0	4
TOTAL	218	145	276	125	227	102	129	61	146	74	160	86	151	106	122	161	35	155	1464	1015

Table 4.4 Admissions from the A&E department by age, sex and specialty 1979-1980.

DAY	0-9		10-19		20-29		30-39		40-49		50-59		60-69		70-79		80+		TOTAL	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
MONDAY	11	10	50	28	56	18	23	13	10	6	11	6	9	7	4	5	0	1	174	94
TUESDAY	4	10	67	25	39	19	24	3	12	5	14	10	8	7	4	6	2	2	174	87
WEDNESDAY	7	3	76	28	49	15	17	10	14	8	18	11	10	2	3	2	1	3	195	82
THURSDAY	5	5	70	16	47	18	19	9	12	10	4	9	2	7	4	6	3	2	166	82
FRIDAY	8	6	79	34	51	16	27	15	22	13	16	11	9	5	7	4	1	1	220	105
SATURDAY	13	16	86	29	53	14	13	19	10	10	13	12	5	7	2	6	1	0	196	113
SUNDAY	21	11	108	36	43	28	19	10	18	6	5	5	4	8	6	6	1	4	225	114
TOTAL	69	61	536	196	338	128	142	79	98	58	81	64	47	43	30	35	9	13	1350	677

Table 4.5 All road accidents by age, sex and day of week 1979-1980.

YEAR	1973	1974	1975	1976	1977	1978	1979	1980	1981
TOTAL	1927	1685	1663	1759	1676	1897	2157	1943	1724

Table 4.6 Annual totals for RTA's 1973-1981

under twenty-five years, more than one third of accidents in males involved 15-19 year olds compared with 22% in females. On weekdays, peaks corresponding to morning and evening rush-hours were observed, as well as a subsidiary peak between 23.00 and 01.00. 42% of males and 39% of females injured in traffic accidents presented between 17.00 and 24.00 and 60% and 51% respectively between 17.00 and 09.00 the following morning.

Table 4.7 shows the annual totals for emergency general surgical admissions, as well as the monthly sub-totals from 1976 to 1981 inclusive. Once again there was a tendency for numbers to increase during the summer. Moreover the gradual decline in numbers since 1976 was accelerated in 1980 before plateauing.

MONTH	1976	1977	1978	1979	1980	1981	TOTALS
JANUARY	295	331	321	251	240	234	1672
FEBRUARY	307	290	251	227	237	217	1529
MARCH	310	298	307	277	251	253	1696
APRIL	280	278	307	290	229	251	1635
MAY	278	276	330	299	227	247	1657
JUNE	308	298	311	279	251	264	1711
JULY	356	354	347	318	253	258	1886
AUGUST	345	322	305	323	224	246	1765
SEPTEMBER	336	312	308	290	270	273	1789
OCTOBER	335	275	258	304	268	282	1722
NOVEMBER	304	296	282	274	246	276	1678
DECEMBER	331	319	265	234	289	282	1720
TOTALS	3785	3649	3592	3366	2985	3083	20460

Table 4.7 Total emergency general surgical admissions 1976-1981.

4.2.3 Head-Injured Patients: All A & E Attendances:

i. Incidence, Age and Sex:

Six thousand, six hundred and eighty-five patients with head injury attended the department during the study period. These represented 18.2% of all new A&E patients. The increase since the period of the retrospective study was 15.9%, an average rise of 4.7% per annum. Four thousand, four hundred and seventy-two patients were male and two thousand, two hundred and thirteen were female, for a male/female ratio of 2. The overall incidence was 2547/100,000; 3507/100,000 for males and 1639/100,000 for females. Children accounted for 41% of cases, adults aged 15-64 years for 52% (56% males and 45% females) and only 7% (4% males and 13% females) were aged sixty-five years or over. The sex ratio varied from 4.0 in those aged 20-24 years to less than 1 in elderly patients and less than 2 in children under ten and patients aged 40-64 years.

The age and sex distribution is shown in Figure 4.6. Among male attenders the major peak occurred at 15-19 years, thereafter numbers rapidly declined until age 30-34 years after which a slower rate of decline occurred. In addition a lesser peak occurred at 0-9 years. In female patients numbers decreased rapidly from their highest level in 0-4 year olds, except for a minor rise in 15-19 and 30-34 year olds, following which, numbers remained fairly constant in each succeeding age-group until a further rise occurred at 70-74 years. Among elderly patients women outnumbered men. The age-specific distribution (Figure 4.7) in females mirrors the changes described above. However, in males, in contrast to the situation regarding absolute numbers, the age-specific rate was highest in the youngest age-group and declined thereafter with a secondary rise in 15-24 year olds. In both sexes a further sharp rise in the age-specific attendance rate occurred in patients seventy years and above. The female excess in terms of absolute numbers was much reduced when age-specific rates were considered.

The age-distribution of all attenders with head injury is

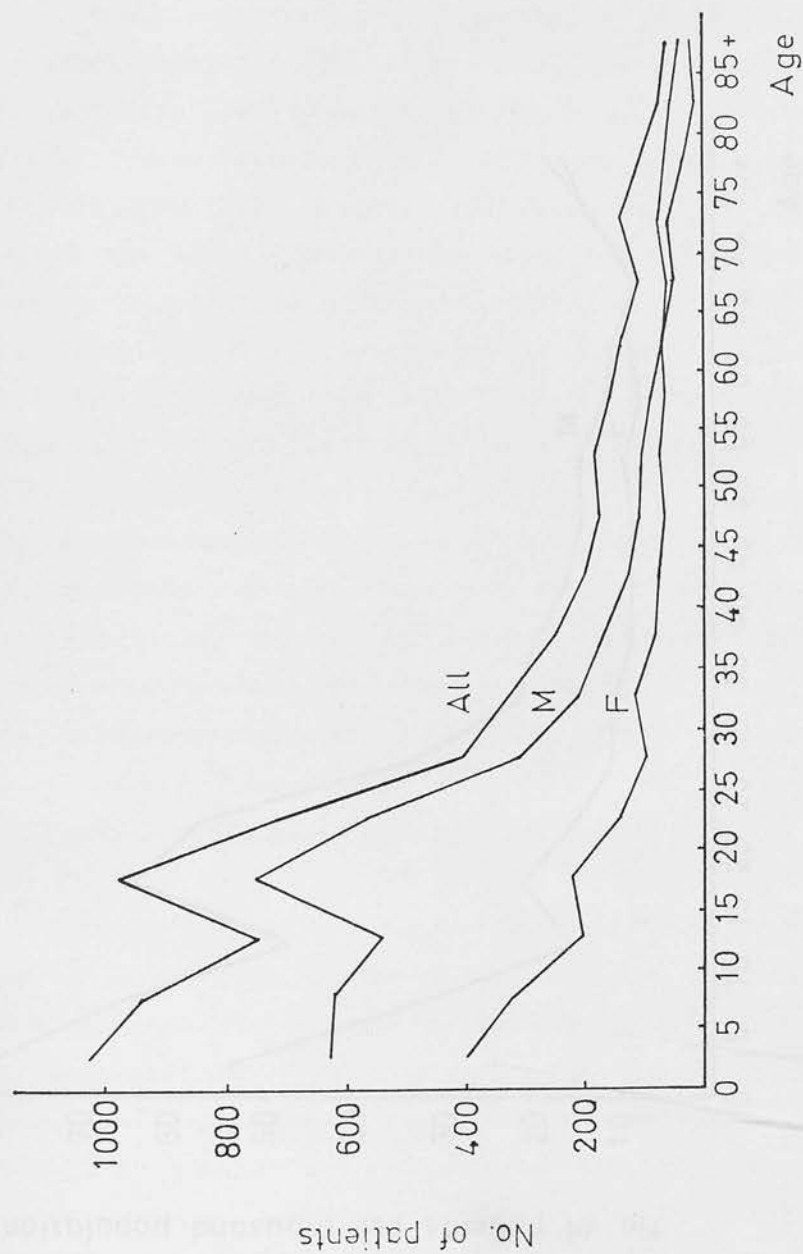


Figure 4.6 Age-distribution of all Head Injuries 1979 - 1980

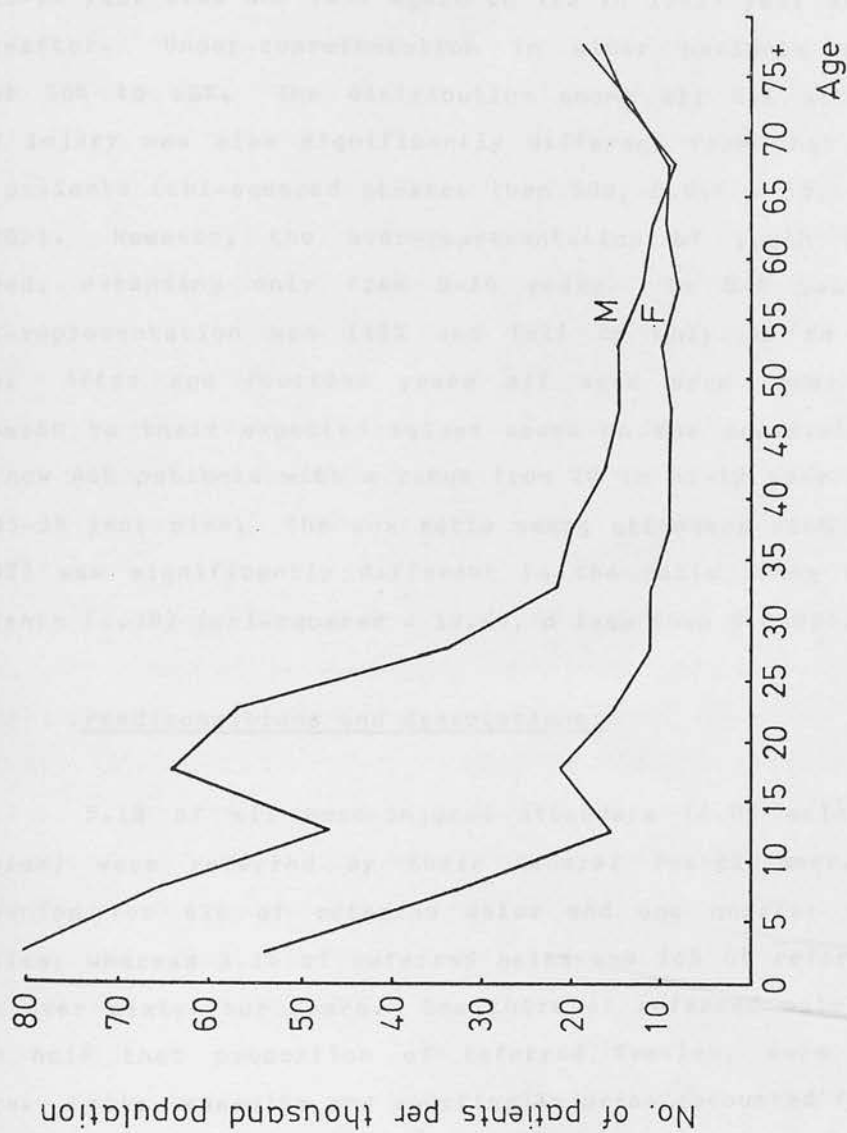


Figure 4.7 Age-specific attendance rates of Head Injuries 1979-1980

significantly different from that of the catchment population (chi-squared greater than 1000, D.O.F = 15, p less than 0.0005). This was due to an over-representation of young people aged 0-24 years and an under-representation of patients twenty-five years and over in the population of attenders with head injury. Over-representation of patients aged 0-4 years was 165%, fell to 27% in 10-14 year olds and rose again to 72% in 15-19 year olds, falling thereafter. Under-representation in older patients ranged from about 10% to 66%. The distribution among all A&E attenders with head injury was also significantly different from that of all new A&E patients (chi-squared greater than 600, D.O.F = 15, p less than 0.0005). However, the over-representation of youth was not as marked, extending only from 0-14 years. In 0-4 year olds the over-representation was 111% and fell to only 3% in 10-14 year olds. After age fourteen years all ages were under-represented compared to their expected values based on the age-distribution of all new A&E patients with a range from 2% in 15-19 year olds to 42% in 35-39 year olds. The sex ratio among attenders with head injury (2.02) was significantly different to the ratio among all new A&E patients (1.78) (chi-squared = 19.67, p less than 0.0005).

ii. Predispositions and Associations:

5.1% of all head-injured attenders (4.0% males and 7.3% females) were referred by their General Practitioner. Children accounted for 42% of referred males and one quarter of referred females, whereas 5.1% of referred males and 26% of referred females were over sixty-four years. One third of referred males, but less than half that proportion of referred females, were aged 15-24 years. Falls, assaults and sporting injuries accounted for 35%, 15% and 11% of male G.P. referrals and 56%, 5.6% and 6.9% of female referrals.

Recent alcohol consumption was noted in four hundred and thirty attenders (6.4%), three of whom were under fifteen years old, all three were boys. Among adults 11% were noted to have been drinking, 13% of men and 5.5% of women. Over two fifths of men and

nearly one sixth of women, who had recently consumed alcohol, were aged 15-24 years, only 5.9% and 5.6% respectively were over sixty-four years old. In men recent alcohol consumption was most often associated with assaults (36%), falls (35%) and driving vehicles (11%) whereas in women it was most common in patients who had fallen (51%) or been assaulted (24%).

Epileptics accounted for only 0.8% of attenders and nearly all sustained their head injury during a fit; males and females were equally represented. Approximately equal proportions of male (20%) and female (22%) epileptics were aged 20-24 years. Generally, epileptics presenting with head injury were young adults and rarely children or elderly patients e.g., boys and girls accounted for only 9.4% of epileptics with head injury. Thirty-three of the thirty-five male epileptics were injured in falls and the two remaining patients had fallen from their bicycles. All eighteen female epileptics sustained their head injury as the result of a fall precipitated by a fit.

Cardiovascular predispositions occurred in 1.9% overall and were much commoner in females (3.6%) than in males (1.1%). Such associations were particularly common in older patients. Among male patients 52% were over sixty-four years old, as were 39% of female patients. The other major age-group in women was 10-19 year olds, who accounted for 19% of female cases with cardiovascular predispositions compared with only 6% of males. 88% of males with cardiovascular predispositions were injured in falls, whereas 98% of females were so injured.

Altogether thirty-three patients (0.5%) were attended by the Flying Squad, twenty were males and thirteen were females. One fifth of the male patients were aged 15-19 years and two-fifths were aged 15-29 years. Among the female patients 23% were aged 15-29 years and the same proportion were aged 70-74 years. Car drivers accounted for 55% of male patients, front-seat passengers for 15% and motorcyclists and pedestrians for a further 10% each. The only male patient not injured in a traffic accident had been injured at

work. All of the female patients attended by the Flying Squad had been injured in traffic accidents. One patient was a pedestrian and the remainder were equally divided between car-drivers, front-seat and rear-seat passengers.

iii. Causes:

The causes of injury in all patients and in males and females separately are shown in Figure 4.8. In both sexes the ranking of the three commonest causes was the same although quantitative differences did occur. Falls were relatively more common in females than males (44% versus 28%) and assaults were less common (8.6% versus 14%), whilst road accidents were about equally common (18% versus 16%). Ranking of causes thereafter followed a predictable pattern, such that industrial accidents, sports injuries and falls off bicycles were commoner in males. In men, injuries sustained at work ranked fifth after sport, whereas in women, accidents at work ranked sixth, sport ranked fifth and head injuries resulting from falls from bicycles ranked fourth. The latter, although relatively more common in males, was ranked sixth. Industrial injuries were four times and sports injuries twice as common in males as females. Non-accidental injury accounted for only ten cases of head injury and was four times as common in girls.

Subdivision of traffic accidents revealed some interesting sex differences (Figure 4.9). Pedestrian injuries were almost equally common (12% males and 14% females) but cyclists accounted for nearly four times as many male head injuries (56 cases) as female head injuries (16 cases). Motorcycle accidents leading to head injury occurred almost exclusively in males, 82% of all such injuries occurring in men. Riders accounted for more than four times as many head injuries from traffic accidents in males as in females, but pillion-passengers accounted for 5.1% of head injuries due to traffic accidents in females and only 2.1% in males. The proportion of traffic injuries occurring in male drivers (37%) was almost double the proportion due to this cause in women (23%). However, women were almost three times as likely to be injured as



All patients (6685)



Males (4472)



Females (2213)

Figure 4.8 Causes of Head Injuries 1979-1980



(PED=pedestrian, CYC=cyclist, MC1=motorcycle rider, MC2 = pillion-passenger, C1=driver, C2 = front-seat passenger, C3 = rear-seat passenger)

Figure 4.9 Classification of RTAs

front-seat passengers as men (28% versus 9.5%) and also about three times as likely to be injured as rear-seat passengers (21% versus 7.7%). Dealing in absolute numbers only the male/female ratio for motorcycle riders was 8.6, for pillion-passengers was 0.75 and for all motorcyclists was 4.7. Similarly the male/female ratio for front-seat passengers was 0.6 and for rear-seat passengers was 0.7, but for drivers was 3, and for all vehicle occupants was 1.4. All told, vehicle occupants accounted for 54% of male and 72% of female head injuries due to road accidents.

Causes of injury also varied with age. Among children 44% of boys and 49% of girls sustained their injuries as the result of a fall. Over the age of sixty-four years, 79% of women and 64% of men were injured in falls, compared with only 13% of men and 29% of women aged 15-64 years. One third of all assaults in males occurred in young adults (15-19 years) and nearly two-thirds in 15-24 year olds. In women most assaults (19%) occurred in 30-34 year olds, only 15% occurred in 15-19 year olds and 31% in 15-24 year olds. Head injuries sustained at work were commoner in young men. Thus 15-19 and 20-24 year olds accounted for 17% and 16% of such injuries in men, each succeeding quinary age-group accounted for a slowly diminishing proportion of industrial injuries. The age-distribution of work accidents among women was essentially similar to that in men. Sporting accidents also occurred most commonly in the younger age-groups. Nearly two-thirds of male head injuries resulting from sport occurred in 10-24 year olds and a similar proportion of such injuries in women occurred in the second decade. No sports related injuries occurred in women over forty-nine or men over fifty-four years. Likewise none occurred in children under five. Falls from bicycles were also the preserve of youth. Nearly one third of males so injured were aged 10-14 years. Among females 45% were 5-9 year olds and 22% were aged 10-14 years. Pedestrians were most often children or elderly people. Half of all male pedestrians were children and 15% were aged sixty-five years or more, whereas 41% of female pedestrians were children and 14% were aged sixty-five years or over. Approximately two fifths of both male and female pedestrians were aged 5-14 years. The majority of cyclists were

young people, 30% of male and 44% of female cyclists being 10-14 years of age. More than two thirds of male and three quarters of female cyclists were aged 5-19 years. Half of all motorcycle riders were aged 15-19 years and a further 22% were aged 20-24 years. Nearly two thirds of female motorcyclists and pillion-passengers were 15-24 year olds. Male vehicle drivers were most often aged 20-24 years (23%) as were female drivers (18%). Proportions thereafter declined steadily as age increased. 29% of male and 18% of female front-seat passengers were aged 15-19 years. Half of all female and slightly fewer male front-seat passengers were aged 15-29 years. More than one in five male and female rear-seat passengers were 15-19 year olds. This variation in causes with age and sex is summarised in Table 4.8.

CAUSE	ALL AGES		0-14 YEARS		15-64 YEARS		65 + YEARS	
	n=6685		n=2712		n=3503		n=470	
	M%	F%	M%	F%	M%	F%	M%	F%
ASSAULT	14	8.6	1.3	1.8	23	17	2.2	0.7
INDUSTRY	7.6	1.9	0	0	13	4.2	3.9	0
SPORT	8.3	3.2	4.9	3.6	11	3.7	0	0
FALL	28	44	44	49	13	29	64	79
FALL BIKE	5.1	3.9	9.8	7.3	2.1	1.9	0	0.3
PEDESTRIAN	1.9	2.5	2.4	2.5	1.2	2.5	7.3	2.7
CYCLIST	1.3	0.7	1.3	1.1	1.2	0.6	1.7	0
MOTORCYCLIST	4.2	1.8	.06	0	7.4	4.0	0	0
CAR DRIVERS	6.0	4.1	0	0	10	8.6	10	1.4
F. PASSENGER	1.5	4.9	0.3	0.5	2.4	9.4	2.2	3.4
R. PASSENGER	1.3	3.8	1.0	2.8	1.4	4.4	1.1	4.5
OTHER	22	21	35	32	13	15	7.3	7.5
TOTAL [100%]	4472	2213	1790	922	2504	999	178	292

Table 4.8 Causes of head injury by age group and sex: All A&E attenders 1979-1980.

The wearing of crash helmets or seat belts would have been appropriate in seven hundred and sixty-five cases, however, only 33% definitely took this precaution. Assuming that all those injured in motorcycle accidents wore helmets, which seems very likely, then only about one in twenty drivers and front-seat passengers definitely wore seat belts.

iv. Temporal Relationships:

The hourly distribution of attendances in both males and females is shown in Figure 4.10. In males attendances increased to a small mid-day peak (12.00-13.00 hours) and continued to rise to a higher peak in the late afternoon (16.00-17.00 hours) before falling again and finally peaking around midnight. In females a broad flat peak occurred in the afternoon (14.00-17.00 hours) shortly followed by a higher briefer peak (18.00-19.00 hours). No late night peak occurred although the rate of decline in numbers was arrested around the same time as the late night peak in males. In boys peaks occurred at 14.00-15.00 and 17.00-18.00 hours, while in girls they occurred at 12.00-13.00, 14.00-15.00, 16.00-17.00 and 18.00-19.00, each peak being higher than the preceding one. Most of the late night peak was accounted for by increased attendances by young adults. More than half of male attendances between 23.00 and 01.00 hours were by patients aged 15-24 years, compared to two-fifths of female attendances. Overall 53% of female and 47% of male attenders presented between 09.00 and 17.00 hours and a further 37% of females and 39% of males attended between 17.00 hours and midnight.

Dividing the hourly distribution of all attenders with head injury into equal periods of three hours (07.00-09.59, 10.00-12.59 etc) and comparing this to the distribution among all new A&E patients, showed a significant difference (chi-squared greater than 200, D.O.F. = 7, p less than 0.0005). Head injury attenders were over-represented during the evening and night and under-represented during the daytime, compared to their expected values.

The attendance of patients injured in falls gradually

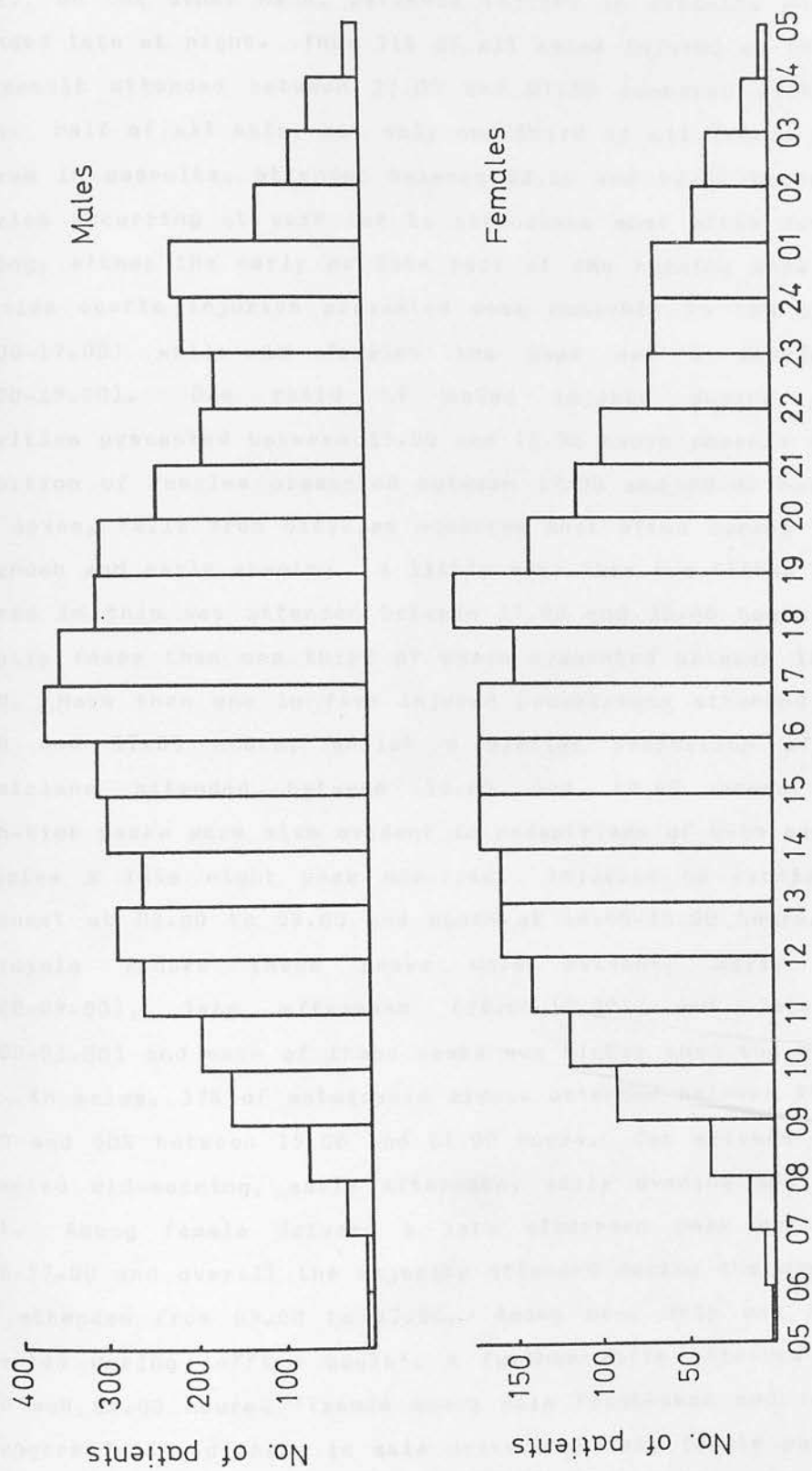


Figure 4.10 Hourly distribution of Head Injuries 1979 - 1980

increased in frequency with time, reaching a maximum at 17.00-18.00 hours, such that about one in five presented between 16.00 and 18.00 hours. On the other hand, patients injured in assaults most often attended late at night. Thus 31% of all males injured as the result of assault attended between 23.00 and 01.00 compared with 26% of women. Half of all male, but only one third of all female patients injured in assaults, attended between 22.00 and 02.00 hours. Head injuries occurring at work led to attendance most often during the morning, either the early or late part of the morning work period. In males sports injuries presented most commonly in the afternoon (15.00-17.00) while in females the peak was a little later (17.00-19.00). One third of males injured during sporting activities presented between 15.00 and 18.00 hours whereas the same proportion of females presented between 17.00 and 20.00 hours. In both sexes, falls from bicycles occurred most often during the late afternoon and early evening. A little more than two-fifths of males injured in this way attended between 17.00 and 20.00 hours whereas slightly fewer than one third of women presented between 16.00 and 19.00. More than one in five injured pedestrians attended between 16.00 and 17.00 hours, whilst a similar proportion of female pedestrians attended between 18.00 and 19.00 hours. Minor lunch-time peaks were also evident in pedestrians of both sexes, and in males a late night peak occurred. Injuries to cyclists were commonest at 08.00 to 09.00 and again at 16.00-18.00 hours. Among motorcycle riders three peaks were evident, early morning (08.00-09.00), late afternoon (16.00-17.00) and late night (23.00-01.00) and each of these peaks was higher than the preceding one. In males, 37% of motorcycle riders attended between 19.00 and 01.00 and 60% between 15.00 and 01.00 hours. Car drivers commonly presented mid-morning, early afternoon, early evening and late at night. Among female drivers a late afternoon peak occurred at 16.00-17.00 and overall the majority attended during the day. Thus half attended from 09.00 to 17.00. Among men, only one in three presented during 'office hours', a further fifth attended between 22.00 and 01.00 hours. Trends among male front-seat and rear-seat passengers followed those in male drivers whereas female passengers were more likely to attend late at night than were women drivers.

Figure 4.11 shows the daily distribution for all patients and for males and females separately. For all patients the average daily attendance was 18.3 but for Saturdays only was 21.2. A steady rise in attendances from their lowest value on Mondays to their highest at weekends, particularly on Saturdays, occurred in males. One third of all male attendances took place on Saturdays and Sundays. Among females, attendances fell from a high level on Mondays before rising again to their highest levels on Fridays and Saturdays, with the level on Sundays also being fairly high. Almost one third of female attendances occurred on Fridays and Saturdays. Among children, Sundays were the commonest days of attendance in boys and Thursdays the other common day and in girls Fridays. More than one in five males aged between 15-19 years attended on Saturdays and almost as many on Sundays compared to only one in six women of the same age.

The daily distribution among all attenders with head injury is significantly different from that among all new A&E patients (chi-squared = 40.58, D.O.F = 6, p less than 0.0005), and from a distribution in which equal numbers are assumed to attend on each day of the week (chi-squared = 65.81, D.O.F = 6, p less than 0.0005). These differences were due to an under-representation of head injury attenders during the early part of the week, especially Mondays, and an over-representation at weekends, especially Saturdays. Using the "zI test" showed that attendances on Mondays, Tuesdays and Wednesdays were significantly lower and on Saturdays and Sundays significantly higher than expected assuming equal numbers to attend on each day of the year.

In males 27% of all assaults attended on Saturdays and 63% attended on Fridays, Saturdays or Sundays. Among females 36% of patients injured in assaults presented on Saturdays or Sundays. In contrast and predictably, industrial accidents did not often present at weekends, but most often attended on Tuesdays. Sporting injuries most often presented on Saturdays in males and Mondays in females. A small mid-week rise also occurred in males. The frequency of attendance by patients injured in falls increased steadily to a peak

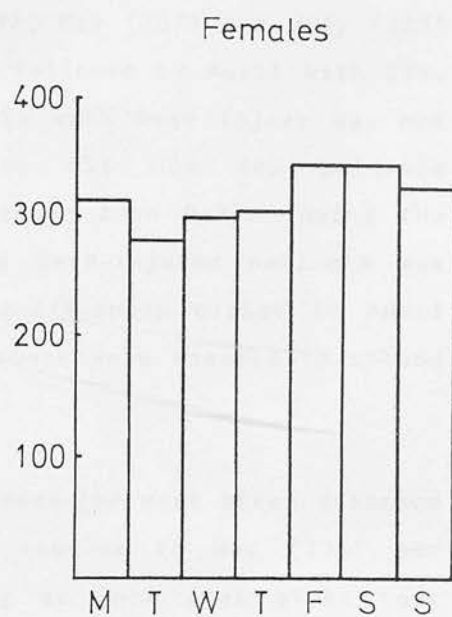
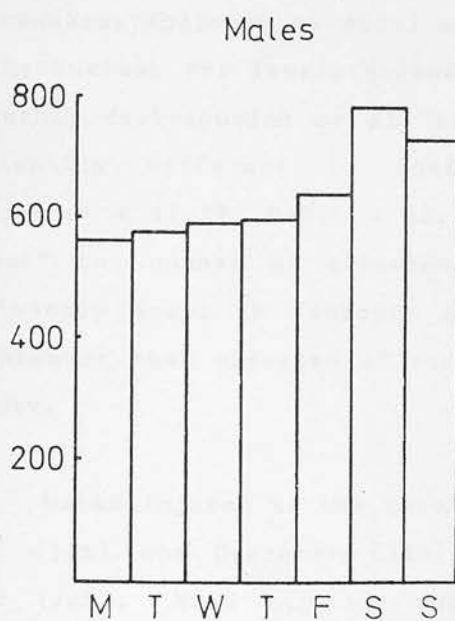
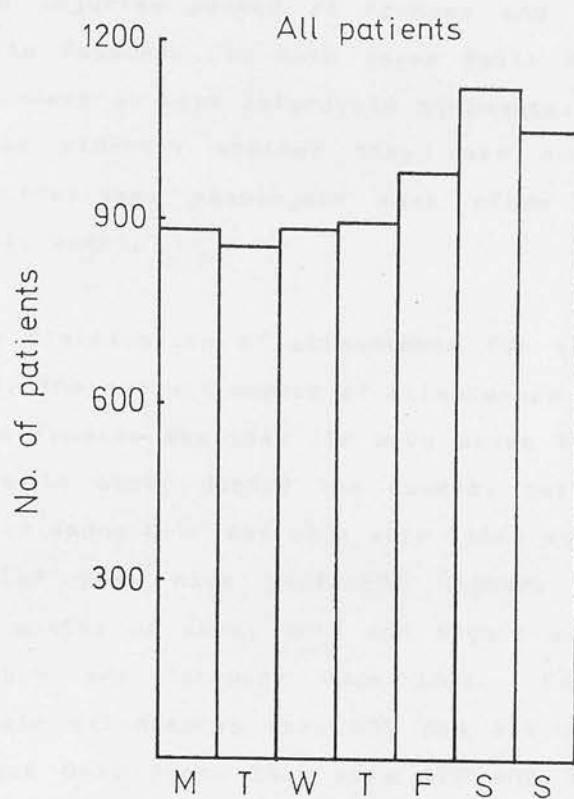


Figure 4.11 Daily distribution of Head Injuries 1979-1980

at weekends, particularly Saturdays in males but Fridays in females. Pedestrian injuries peaked on Fridays and Saturdays in males and mid-week in females. In both sexes falls from bicycles were commonest on Sundays as were motorcycle accidents. Car drivers most often presented mid-week whether they were men or women, whereas front and rear-seat passengers most often attended at weekends, particularly women.

The monthly distribution of attendances for both sexes is shown in Figure 4.12. The average number of attendances per month in males was 373 and in females was 184. In both sexes the trend was for more attendances to occur during the summer, particularly in children. Attendances among 0-4 year olds were twice as high in the summer and among 5-9 year olds were 80% higher. Total male attendances for the months of June, July and August were 1113 and for December, January and February were 1021. For the same quarters, total female attendances were 600 and 510 respectively. However for boys aged 0-14 years they were 520 and 333, and for girls 271 and 177. In males September was the busiest month and had 411 attenders, followed by April with 395; May (207) and July (203) were the busiest for female attendances followed by April with 199. The monthly distribution of all attenders with head injury was not significantly different to that among all new A&E patients (chi-squared = 12.59, D.O.F = 11, p greater than 0.3). Using the "zI test" the number of attendances by head-injured patients was significantly lower in February and significantly higher in April and September than expected if equal numbers were assumed to attend every day.

Males injured as the result of assaults most often attended in May (11%) and December (11%), and females in May (13%) and October (12%). Head injuries occurring at work most often took place in March and April and least often in August, when there were half as many cases. March and April were also the most common times for females to be injured during sporting activities, whereas in males such injuries were commonest in November with further increases in March, April and September. Two peaks occurred in the

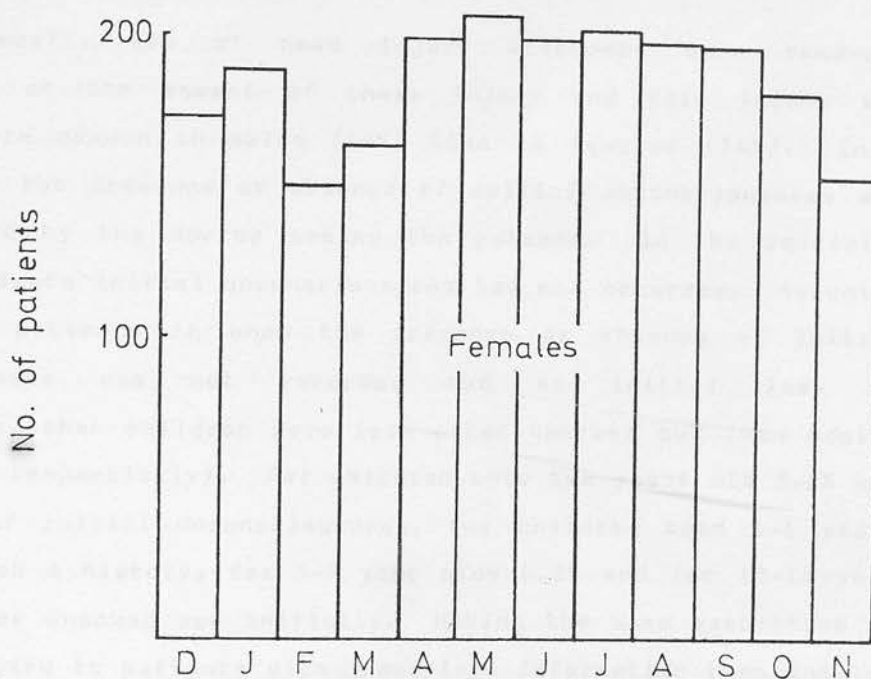
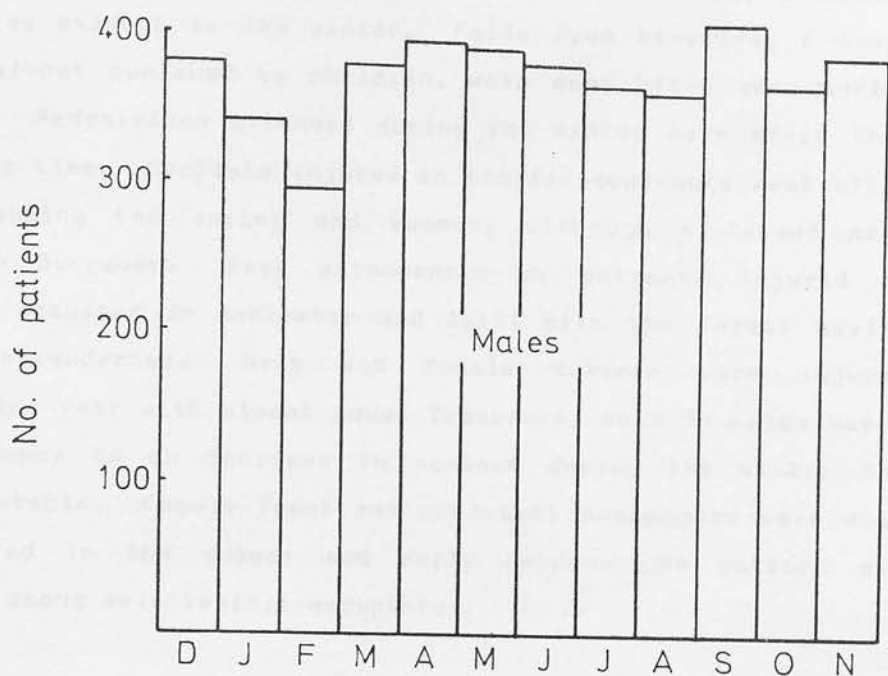


Figure 4.12 Monthly distribution of Head Injuries 1979-1980

distribution of patients injured as the result of falls. Overall these injuries were most common in the summer, however, a lesser peak was also evident in the winter. Falls from bicycles, a cause of injury almost confined to children, were most often seen during the summer. Pedestrians attended during the winter more often than at any other time. Cyclists injured in traffic accidents most often presented during the spring and summer, although a lesser peak occurred in December. Peak attendances by patients injured on motorcycles occurred in September and April with the former having the more attendances. Male and female drivers were injured throughout the year with almost equal frequency, only in males was a slight tendency to an increase in numbers during the winter and summer detectable. Female front and rear-seat passengers were most often injured in the summer and early autumn. No pattern was discernible among male vehicle occupants.

v. History Symptoms and Signs:

Overall, 15% of head injury attenders were rendered unconscious at the moment of their injury and this factor was slightly more common in males (16%) than in females (14%). In a further 35% the presence or absence of initial unconsciousness was not recorded by the doctor seeing the patient. In the remaining half of patients initial unconsciousness had not occurred. Assuming that those patients in whom the presence or absence of initial unconsciousness was not recorded had no initial loss of consciousness, then children were less often knocked out than adults (9% and 18% respectively). For children upto two years old 3.5% had a history of initial unconsciousness, for children aged 2-4 years 5.2% had such a history, for 5-9 year olds 8.2% and for 10-14 year olds 16% were knocked out initially. Making the same assumption as above in regard to patients with incomplete information then initial loss of consciousness was most common in patients of both sexes injured in traffic accidents and least common as the result of sports injury in males and as the result of falling off bicycles in females. For males injured in road accidents the proportions initially knocked out were 67% (pillion-passengers), 55%

(pedestrians), 42% (motorcycle riders), 35% (front-seat passengers), 31% (vehicle drivers), 29% (cyclists) and 14% (rear-seat passengers). For all road traffic accidents as a group the proportion was 36%. For non-traffic accidents in males the proportions who initially lost consciousness were 16% (falls from bicycles), 15% (assaults and falls), 14% (industrial) and 11% (sports). Among female patients loss of consciousness following road traffic accidents was less common than in males - 35% (motorcycle riders and pillion-passengers), 29% (pedestrians), 25% (cyclists), 21% (vehicle drivers), 20% (front-seat passengers) and 19% (rear-seat passengers). Considering all traffic accidents as one group, then 23% of women so injured were rendered unconscious at the moment of injury. For non-traffic accidents the proportions of females with initial unconsciousness were 24% (sport), 13% (assaults and falls), 12% (industrial) and 8% (falls from bicycles). Of all episodes of unconsciousness in females 42% were the result of falls and 30% the result of road traffic accidents whereas in males 38% resulted from traffic accidents and only 26% resulted from falls. Initial unconsciousness occurred in 55% of all patients who had a skull fracture on X-ray, whereas 29% were definitely not rendered unconscious initially and in the remaining 16% this fact was unrecorded. Initial loss of consciousness was more common in males with skull fracture on X-ray (63%) than in females (39%).

Post-traumatic amnesia of any duration occurred in 7.2% of all male and 6.3% of all female attenders with head injury. This feature was definitely absent in a further 11% of both males and females. However in the remaining 82% of males and females the presence or absence of this factor was not recorded. One child under five years old was recorded as having amnesia and fifty-seven were recorded as not having amnesia. Generally speaking the same relationships between amnesia and cause, age and sex were found as detailed above for the incidence of initial loss of consciousness. In females 35% of all episodes of amnesia followed falls and 45% resulted from traffic accidents, whereas in males 19% followed falls and 47% followed traffic accidents. Amnesia occurred in 21% of all patients with a fracture on skull X-ray, was absent in 6.9% and was

unrecorded in 72%.

Vomiting occurred in 6.7% of all patients following head injury and was more common in females (8.1%) than males (6.0%). Absence of this symptom definitely occurred in 45% of males and 46% of females. Vomiting was also more common in children (9.9%) than in adults (4.5%) and was commoner in girls (12%) than in boys (8.9%). Three fifths of all episodes of vomiting occurred in children and 83% occurred in patients under thirty years old. Falls provoked nearly half of all episodes of vomiting in both sexes, whereas road accidents were associated with only one out of every seven episodes. Among patients with a skull fracture on X-ray vomiting occurred in 33% of all cases, 35% of males and 28% of females.

In 34% of all attenders with head injury the presence or absence of neurological signs was not recorded, a further 61% definitely had no neurological signs present on initial presentation to the A&E department and the remaining 4.8% did have neurological signs. Most often these signs were a depressed conscious level, usually noted as drowsiness on examination. Neurological signs were present in 5.1% of female and 4.7% of male attenders. Such signs were least common in children (4.2%) and most common in elderly patients (7.2%) with adults intermediate (5.1%). In children signs were commoner in girls (4.8%) than boys (3.9%), in adults the sex incidence was equal (5.1%) and in elderly patients, signs were present more often in males (8.4%) than females (6.5%). Road traffic accidents accounted for 42% of all male cases with signs, but 35% of all females with signs, whereas falls were responsible for 29% of male and 46% of female cases with signs. Traffic accidents were associated with the presence of signs in 12% of cases in males and 9.9% of cases in females. The proportions of males with signs for each type of traffic accident were: pedestrians 23%, pillion-passengers 20%, cyclists 16%, motorcycle riders and front-seat passengers 12%, vehicle drivers 9.6% and rear-seat passengers 3.6%. Similarly for females the proportions were: pedestrians 20%, cyclists 19%, motorcycle riders 15%,

pillion-passengers 10%, rear-seat passengers 8.4%, front-seat passengers 7.3% and drivers 5.6%. For non-traffic accidents the proportion of males with signs were as follows: falls from bicycles 5.7%, falls 5%, assaults 2.8%, industrial 2.7% and sport 2.4%, and for females sport 8.8%, falls 5.4%, falls from bicycles 4.6%, assaults 0.5% and industrial nil. The presence or absence of signs was unrecorded in 2.6% of all cases who had a fracture on skull X-ray, 41% had signs and 57% did not. Of all cases with neurological signs, 15% had a skull fracture on X-ray. Skull fracture on X-ray occurred in 1.1% of patients who did not have neurological signs.

vi. Plain X-Rays:

Altogether two thousand, six hundred and three patients (39%) had plain skull films and a hundred and seventeen of these (4.5%) had skull fractures and/or diastasis confirmed by the radiologist. Assuming patients not X-rayed had no skull fracture then the overall incidence of radiologically proven fracture was 1.8%. Clearly, fractures present in patients brought in dead or fractures diagnosed clinically would add to this result. Twenty-eight (24%) of the patients with a radiologically proven fracture were also recognised as having a fracture clinically, according to the presence of bilateral palpebral bruising, bleeding from the ears, etc. An additional twenty-one patients were diagnosed clinically as having a fracture of the skull, usually basal, and either had no X-ray or normal skull X-rays. Five of these twenty-one patients subsequently died and all five had skull fractures present at post-mortem. Including these clinical only cases and fifteen patients brought in dead who also had fractures at post-mortem as well as three other patients with skull fractures at autopsy only, the total number of patients with skull fracture was one hundred and fifty-six (2.3%).

Of patients with a radiologically proven fracture, 55% had initially become unconscious, 21% had a period of amnesia, 33% had vomited and 41% had neurological signs. These proportions are four,

three, five and eight times the respective proportions in the whole patient population. Each of these relationships to the presence of a fracture on skull X-ray is significant at at least $p = 0.0005$, assuming patients in whom a feature is unrecorded are negative for that feature. Although initial loss of consciousness alone correctly identified more than half of all patients who had a fracture on X-ray, only 6.4% of patients initially knocked out had a fracture. Fractures occurred in 0.9% of patients not initially knocked out but these accounted for 45% of all skull fractures. Similarly 5.4% of patients who were amnesic had a fracture and this finding alone correctly identified one in five radiologically proven fractures. Vomiting occurred in nearly one third of patients with a skull fracture but only 8.5% of patients who vomited had a fracture. Two fifths of patients with a skull fracture on X-ray had neurological signs but only 15% of all patients with signs had a radiologically proven fracture.

The overall male/female ratio for all head injuries was 2 and for radiologically proven fracture was 2.3. The male preponderance was most marked among 15-24 year olds when the ratio was nearly 7. Children were responsible for 41% of attendances and accounted for 41% of fractures. Fractures occurred in 1.8% of children (male/female ratio 1.7), 1.7% of adults (male/female ratio 3.6) and 1.9% of elderly patients (male/female ratio 1.3) whether they were X-rayed or not.

Although road traffic accidents only accounted for 17% of all head injuries they caused one third of all radiologically proven fractures, whereas falls accounted for one third of all head injuries and a slightly lower proportion of fractures. No female attenders sustained fractures as the result of assaults or works accidents, consequently these causes were responsible for a smaller proportion of skull fractures than their frequency as a cause of head injury would suggest. Sports accidents caused fewer, and falls from bicycles more, fractures than their overall incidence indicated they might. The biggest discrepancy however occurred amongst pedestrians who accounted for 2.1% of all head injuries and 13% of

all injuries due to traffic accidents, but 14% of all fractures and 41% of fractures due to traffic accidents. Cyclists accounted for more than four times as many skull fractures as their overall incidence as a cause of head injury would suggest and motorcyclists almost twice as many. Vehicle occupants as a group and individually accounted for a very similar proportion of fractures as their overall incidence as a cause of head injury.

Forty-seven patients were diagnosed as having a 'possible' skull fracture by the A&E staff, i.e., diagnosed as a definite or query fracture by the A&E staff but reported as no bony injury by the radiologist. A further six patients were thought by the A&E doctors to have a 'query' fracture of the skull and in these six cases the films were reported as definite skull fractures. The skull films of three additional patients were thought by both the A&E staff and the radiologist to show an appearance suspicious of a fracture, all three being suspicious of traumatic diastasis. Patients thought to have fractures not confirmed by the radiologist accounted for 1.9% of patients having skull films and 0.7% of all patients with head injury. For every two skull fractures correctly identified on X-ray, an additional patient was suspected of having a fracture when no fracture was present. The acceptability of skull films for diagnostic purposes was not assessed.

Missed skull fractures occurred in twelve patients (10% of fractures) including one patient with a sphenoid fluid level but no visible fracture line. Also included is one patient who was not X-rayed at the time of his initial presentation but was X-rayed three days later when the fracture was identified. Only one of the twelve was initially admitted. The patient who showed a sphenoid fluid level was initially sent home, but presented two days later with a moderate pyrexia, was admitted and recovered uneventfully. None of the patients in whom the presence of a skull fracture was missed came to any harm. Altogether therefore, of one hundred and seventeen patients with a fracture on skull X-ray, 85% were correctly identified, 5% were suspected and 10% were missed.

PART X-RAYED	PERCENTAGE OF PATIENTS HAVING PART X-RAYED	PERCENTAGE OF X-RAYED PATIENTS WITH POSITIVE FINDINGS
SKULL	39	4.5
FACE	5.5	17
NOSE	2.2	63
MANDIBLE	1.7	21
CERVICAL SPINE	5.0	4.8
UPPER LIMB	6.7	54
CHEST	5.6	19
THORACIC SPINE	0.6	17
LUMBAR SPINE	1.2	11
PELVIS	2.0	24
LOWER LIMB	4.5	41
ABDOMEN	0.9	3.2
ANY	49	20

Table 4.9 Proportion of patients X-rayed according to anatomical site

Just under half of all attenders had at least one anatomical part X-rayed. The proportions having each site X-rayed and the proportion of those X-rayed who had positive findings are shown in Table 4.9. The proportion of patients who had limb X-rays was underestimated since no allowance was made for X-raying both sides or for X-raying more than one site in the same limb, e.g., upper arm and forearm. Similarly oblique rib films were sometimes taken of both sides, but could only be recorded as one X-ray. Such films also included a straight chest X-ray. The small proportion of patients who had bilateral rib fractures or combinations of fractures with contusions, haemothorax or pneumothorax were recorded as only one positive finding on chest X-ray. In terms of positive yield only abdominal films were worse than skull X-ray, although only two patients had an abnormality on abdominal X-ray. The highest yield was from X-rays of nasal bones, followed next by limb injuries, particularly upper limb injuries. Fractures of the limbs or limb girdles occurred in 5.9% of all attenders whether X-rayed or not, whereas only 0.2% of all patients had fractures and/or dislocation of the cervical spine.

Slightly more than two thirds of patients X-rayed had only

one part X-rayed, one-fifth had two parts X-rayed, 6.5% had X-rays of three separate anatomical sites, 3.3% of four sites, 1.4% of five sites, 0.7% of six sites, 0.2% of seven sites and one patient had X-rays of eight separate sites. A positive result was obtained in 16% of the five thousand and nine separate sites X-rayed. Six hundred and fifty-five patients had 798 positive findings between them, an average of 1.2 positive findings per patient. 83% had one positive finding, 13% had two positive findings, 2.4% three positive findings and 1.2% had four positive findings. Bilateral limb fractures and two or more fractures in the same limb were not unusual, nor were bilateral chest injuries. However bilateral skull or facial bone fractures were uncommon. Fracture or dislocation of the spine occurred in only thirty-two patients (0.5% of all patients), sixteen cervical, seven thoracic and nine lumbar.

4.2.4 Admitted Patients:

i. Incidence, Age and Sex:

A total of seven hundred and twenty A&E attenders were admitted. Twenty of these patients were initially discharged but were admitted, usually on account of symptoms, when they returned to the A&E later. Seven admitted patients were re-admitted after discharge from the general surgical wards, again usually because they were symptomatic. Five thousand, nine hundred and sixty-five A&E attenders with head injury were not admitted, thirteen of these took their own discharge and a further sixty-one returned to the A&E shortly after their initial presentation because of new or persistent symptoms and were again sent home. Finally, an additional thirty-six patients were brought in dead.

Of the admitted patients three hundred and twenty-four (45%) were admitted because of head injury alone, three hundred and twenty-seven (45%) because of another injury or condition alone and sixty-nine (9.6%) because of a head injury and another injury or condition. Thus there were three hundred and ninety-three head injury admissions representing 1.1% of all new A&E patients and 5.9% of all head injury attenders during the study period. The admission rate for head injuries alone or in combination was therefore 150/100,000 (230/100,000 for males and 90/100,000 for females). Patients admitted because of their head injury alone will be termed uncomplicated and patients admitted because of another injury or condition plus their head injury will be termed complicated.

The male/female ratio for head injury admissions was 2.2 compared with 2.0 for all A & E attenders. In 0-4 year olds this ratio was 0.96 rising to 5.1 in 15-19 year olds, falling thereafter before rising again to 6.0 in 50-54 year olds and then dropping to less than 1.0 in patients over sixty-four years. The age-distribution for all patients and for males and females separately is shown in Figure 4.13. Two out of every five admitted patients were children, only 6.6% were over sixty-four years old.

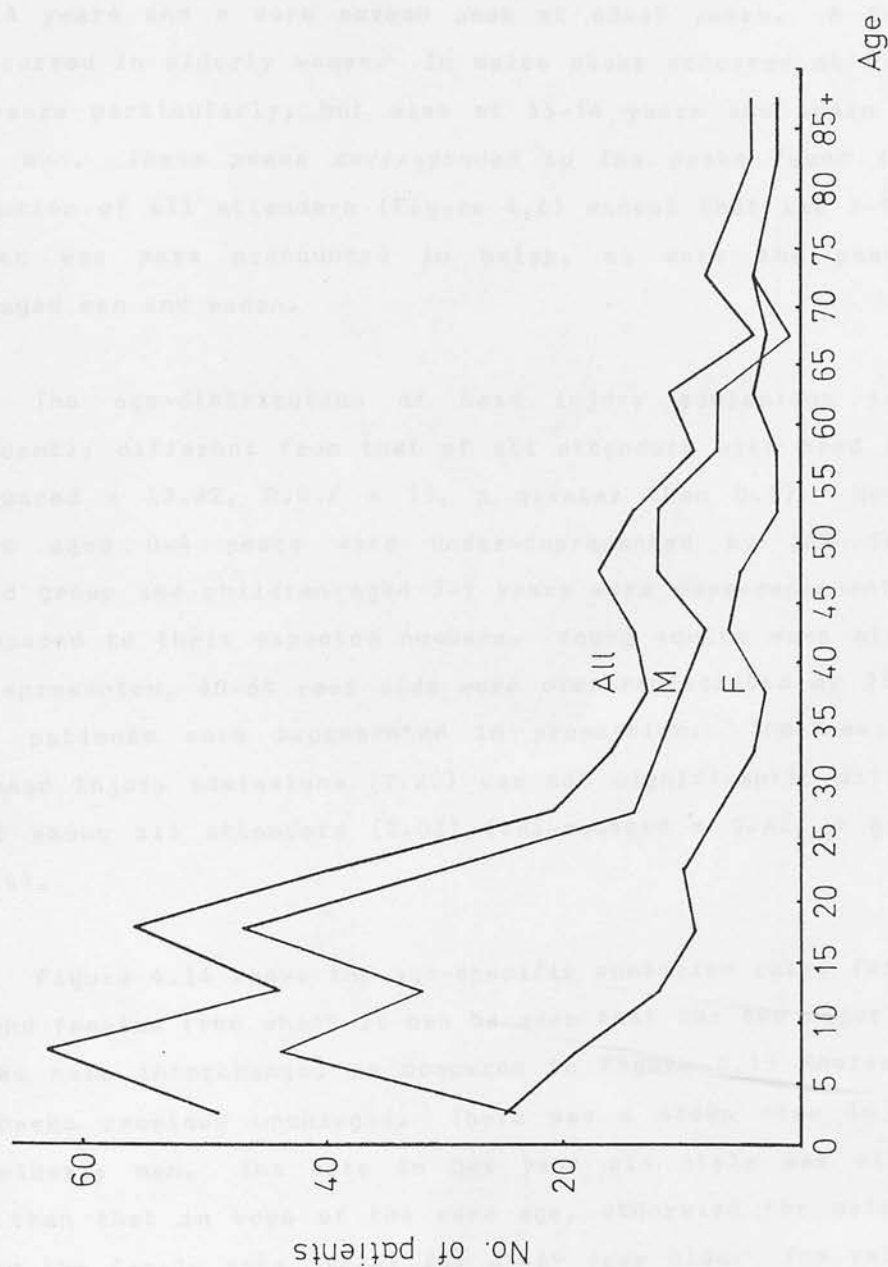


Figure 4.13 Age distribution of admitted Head Injuries 1979-1980

Upto sixty-four years of age the number of males in each age group always exceeded that of females except among 0-4 year olds. After age sixty-four the number of females in each age-group either exceeded or was equal to the number of males. Among females numbers declined steadily from a maximum in 0-4 year olds with a minor peak at 20-24 years and a more marked peak at 40-49 years. A further peak occurred in elderly women. In males peaks occurred at 5-9 and 15-19 years particularly, but also at 45-54 years and again among elderly men. These peaks corresponded to the peaks found in the distribution of all attenders (Figure 4.6) except that the 5-9 year old peak was more pronounced in males, as were the peaks in middle-aged men and women.

The age-distribution of head injury admissions is not significantly different from that of all attenders with head injury (chi-squared = 13.92, D.O.F = 15, p greater than 0.5). However, children aged 0-4 years were under-represented by 28% in the admitted group and children aged 5-9 years were over-represented by 13% compared to their expected numbers. Young adults were slightly under-represented, 40-64 year olds were over-represented by 28% and elderly patients were represented in proportion. The sex ratio among head injury admissions (2.22) was not significantly different to that among all attenders (2.02) (chi-squared = 0.62, p greater than 0.4).

Figure 4.14 shows the age-specific admission rates for both males and females from which it can be seen that the two major peaks in males have interchanged as compared to Figure 4.13 whereas the other peaks remained unchanged. There was a steep rise in rates among elderly men. The rate in 0-4 year old girls was slightly higher than that in boys of the same age, otherwise the male rate exceeded the female rate except for 65-69 year olds. The ratio of rates between the sexes was 2.4 overall but 4.6 among 15-19 year olds. As expected the ratio was lowest at the extremes of life and highest in young adults.

ii. Predispositions and Associations:

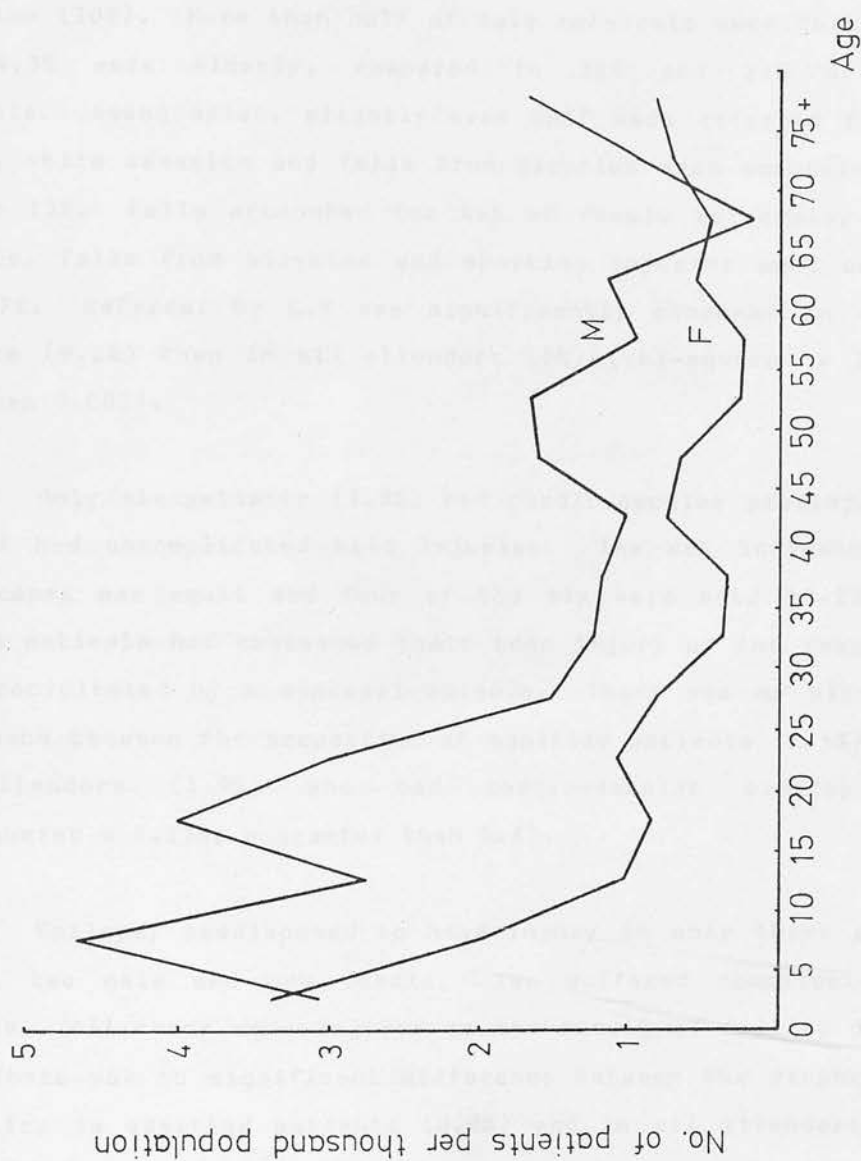


Figure 4.14 Age-specific admission rates for Head Injury 1979-1980

9.2% of head injury admissions were referred to the AED by their General Practitioners and they were more often female (11%) than male (8.5%). Among males referrals were five times as common in patients with uncomplicated head injuries. However, in females referral was slightly more common in patients with complicated head injury (14%) than in patients without additional reasons for admission (10%). More than half of male referrals were children and only 4.3% were elderly, compared to 38% and 23% of female referrals. Among males, slightly over half were referred following a fall, while assaults and falls from bicycles each accounted for a further 13%. Falls accounted for 46% of female referrals, whereas assaults, falls from bicycles and sporting injuries each accounted for 7.7%. Referral by G.P was significantly commoner in admitted patients (9.2%) than in all attenders (5%) (chi-squared = 11.69, p less than 0.001).

Only six patients (1.5%) had cardiovascular predispositions and all had uncomplicated head injuries. The sex incidence among these cases was equal and four of the six were aged 10-29 years. All six patients had sustained their head injury as the result of a fall precipitated by a syncopal episode. There was no significant difference between the proportion of admitted patients (1.5%) and of all attenders (1.9%) who had cardiovascular predispositions (chi-squared = 0.158, p greater than 0.6).

Epilepsy predisposed to head injury in only three patients (0.8%), two male and one female. Two suffered complicated head injuries. All three were injured as the result of falling during a fit. There was no significant difference between the proportion of epileptics in admitted patients (0.8%) and in all attenders (0.8%) (chi-squared = 0.052, p greater than 0.8).

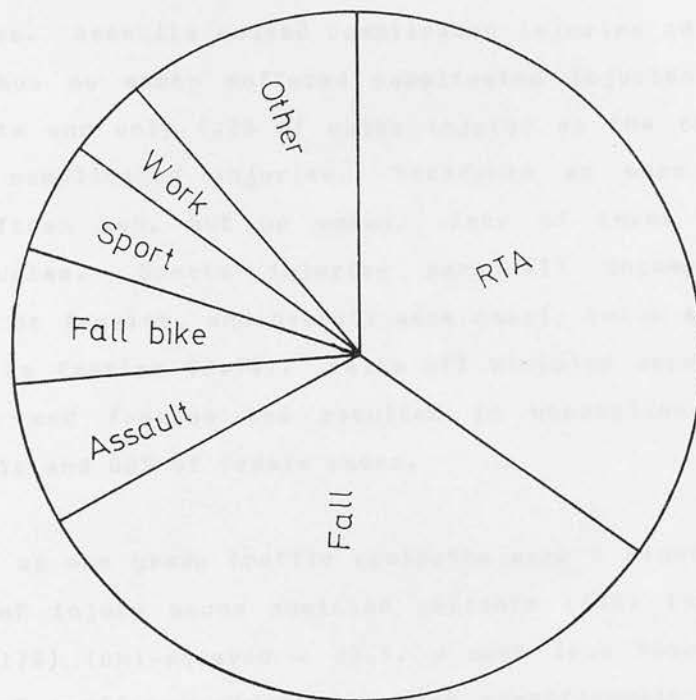
Recent alcohol consumption was the commonest association with head injury, being present in fifty-three males and three females (56 = 14% of all admissions and 23% of adult admissions); thirty-nine males and two females had uncomplicated head injuries. Almost half of all males with uncomplicated head injury were aged

15-24 years whereas more than half of those with complicated injury were aged 25-34 years. The three women were aged 30-44 years. In the forty-one patients in whom head injury alone determined admission, 39% were involved in assaults, 29% had fallen and 26% were injured in traffic accidents (4 pedestrians, 2 drivers and 4 front-seat passengers). All those assaulted or injured in road accidents were male. Of the fifteen patients with additional reasons for admission, the only woman had fallen off a bicycle, whereas half of the men were car drivers, 14% were motorcycle riders and 21% had fallen. Industrial accidents and assaults each accounted for one complicated injury. Recent consumption of alcohol was significantly commoner in adult head injury admissions (23%) than in all adult attenders with head injury (11%) (chi-squared = 33.03, p less than 0.0005).

Thirteen patients (3.3%) were treated by the hospital - based Flying Squad. Nine of these patients were male. Complicated injuries were present in two thirds of the male and three-quarters of the female patients. Only one patient was a child and four were aged 15-24 years. Except for one man injured at work, all these patients had been injured in road traffic accidents. All four women were vehicle occupants (2 drivers, 1 front and 1 rear-seat passenger). Injured males were pedestrians (1), drivers (5) and front-seat passengers (2).

iii. Causes:

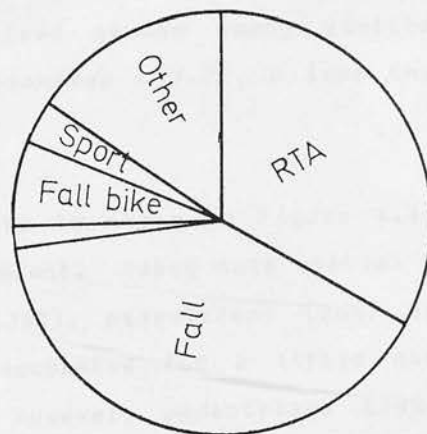
Figure 4.15 shows the causes of injury in all admitted patients and in males and females separately. Road accidents accounted for a little more and falls a little less than one third of all cases. However, in females falls accounted for two fifths and traffic accidents for one third of cases and in males the proportions were 28% and 36% respectively. For all cases admitted on account of head injury alone, falls accounted for 36% and traffic accidents for 26%, but for complicated injuries, road accidents accounted for three-quarters and falls only 13% of cases. Among all causes, assaults and industrial injuries were responsible for only a



All patients (393)



Males (271)



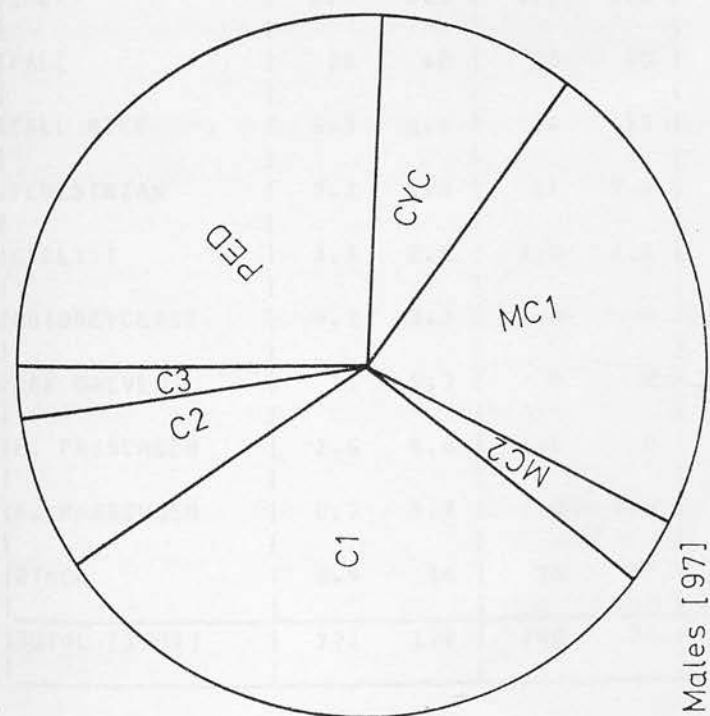
Females (122)

Figure 4.15 Causes of Head Injury admissions 1979-1980

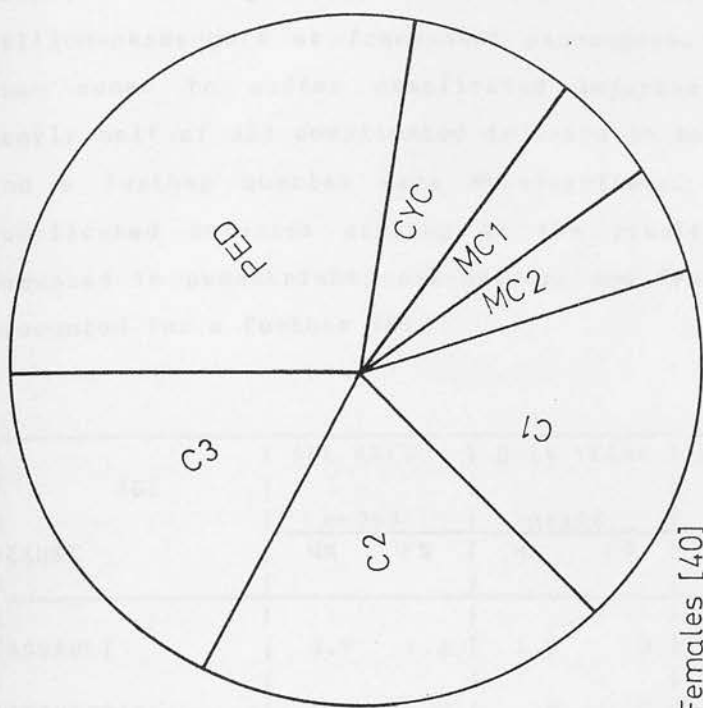
few admissions and were predictably more common in males in whom they accounted for 8.9% and 5.6% of admissions, compared to 1.7% and 0% of female cases. Assaults caused complicated injuries relatively infrequently. Thus no women suffered complicated injuries as the result of assaults and only 4.2% of males injured as the result of an assault had complicated injuries. Accidents at work led to admission in fifteen men, but no women. Four of these men had complicated injuries. Sports injuries were all uncomplicated, whether in males or females, and overall were nearly twice as common in males (6.3%) as females (3.3%). Falls off bicycles were equally common in males and females and resulted in uncomplicated head injury in all male and 88% of female cases.

Treated as one group traffic accidents were a significantly commoner cause of injury among admitted patients (35%) than among all attenders (17%) ($\chi^2 = 83.5$, p much less than 0.0005) each sub-group of traffic accident was also significantly commoner in admitted patients except for those involving pillion-passengers, front-seat and rear-seat passengers. The proportions in regard to the latter three were not significantly different between the two groups. Assaults were significantly less common among admitted patients than among all attenders ($\chi^2 = 9.71$, p less than 0.005).

Subdivision of traffic accidents is shown in Figure 4.16. Quite marked variation with sex was apparent. Among male victims of road traffic accidents, car drivers (30%), pedestrians (26%) and motorcycle riders (23%) between them accounted for a little over three-quarters of cases. In females however, pedestrians (28%), front-seat passengers (20%) and drivers (18%) were responsible for about two-thirds. Males and females were equally often injured as pedestrians or cyclists but males were more than four times as often injured as motorcycle riders and nearly twice as often injured as car drivers. On the other hand, women were injured nearly three times as often as front-seat passengers and eight times as often as rear-seat passengers. Pillion-passengers were slightly more often likely to be women. Even though pedestrians were equally often male



Males [97]



Females [40]

(PED = pedestrian, CYC = cyclist, MC1 = motorcycle rider, MC2 = pillion-passenger, C1 = Driver, C2 = front-seat passenger, C3 = rear-seat passenger)

Figure 4.16 Classification of RTAs

or female, the latter were twice as likely to suffer complicated injuries. Women were also more likely than men to sustain complicated injuries when injured as motorcycle riders, pillion-passengers or front-seat passengers. Men were more likely than women to suffer complicated injuries when driving a car. Nearly half of all complicated injuries in males occurred in drivers and a further quarter were motorcyclists. In women 35% of all complicated injuries arising as the result of traffic accidents occurred in pedestrians, car-drivers and front-seat passengers each accounted for a further 18%.

AGE	ALL AGES		0-14 YEARS		15-64 YEARS		65 + YEARS	
	n=393		n=156		n=211		n=26	
CAUSE	M%	F%	M%	F%	M%	F%	M%	F%
ASSAULT	8.9	1.6	1.0	0	14	3.8	0	0
INDUSTRIAL	5.5	0	0	0	9.4	0	0	0
SPORT	6.3	3.3	4.0	1.8	8.2	5.8	0	0
FALL	28	40	45	50	17	25	42	57
FALL BIKE	6.3	6.6	14	11	1.9	3.8	0	0
PEDESTRIAN	9.2	9.0	11	7.1	5.0	9.6	50	14
CYCLIST	3.3	2.5	3.0	1.8	3.8	3.8	0	0
MOTORCYCLIST	9.2	3.3	1.0	0	15	7.7	0	0
CAR DRIVERS	11	5.7	0	0	18	13	8.3	0
F. PASSENGER	2.6	6.6	1.0	0	3.8	12	0	14
R. PASSENGER	0.7	5.7	2.0	3.6	0	5.8	0	14
OTHER	8.9	16	18	25	3.8	9.6	0	0
TOTAL [100%]	271	122	100	56	159	52	12	14

Table 4.10 Causes of head injury by age and sex: Admitted patients 1979-1980.

As well as varying with sex, causes of injury also varied with age (Table 4.10). Falls were commoner in children and elderly patients, accounting for about half of the cases in these age groups but only one in five adult cases. At all ages, falls were commoner in females and rarely caused complicated injuries. Assaults were four times as common in males as females and also only occasionally resulted in complicated injuries. Two thirds of male and half of female assaults occurred in 15-29 year olds, with 15-19 year old males accounting for a third of male cases. The ratio of the number of assaults in males: females was 11.5. Injuries at work occurred only in adult males and accounted for 9.5% of injuries in that group; about one in four were complicated injuries. Sports accidents were twice as common in adults as in children and did not occur at all in the elderly. Such injuries were all uncomplicated and were commoner in boys and men; two-thirds were aged 15-24 years. Falls off bicycles were more common in children than in adults and were not recorded at all in the elderly. These accidents did not cause complicated injury in children but in adults one in five were associated with complicated injuries. The sex incidence was about equal and 80% of patients were aged 5-14 years.

Among pedestrians children predominated, accounting for 42% of all pedestrians injured, whereas elderly patients accounted for 22%. However head injuries to pedestrians accounted for 31% of all admissions in the elderly, 6.2% in adults and 9.6% in children. Children and elderly patients injured as pedestrians were more often male than female, whilst in the adult group the reverse was true. This sex difference was most marked in the elderly. Also, in the elderly of either sex, pedestrians were equally likely to have complicated or uncomplicated injuries, whereas adults and children were two or three times as likely to have uncomplicated as complicated injuries. One third of all pedestrians had other injuries themselves meriting admission, in addition to their head injury.

The peak age incidence for cyclists injured in road accidents was a little higher than in those injured when falling off

their bicycles. One third of all cyclists were aged 15-19 years and one quarter 5-14 years. Surprisingly, no cyclist had additional reasons for admission. Proportionately cyclists were as often male as female, although on a numerical basis the male/female ratio was 3. One pillion-passenger was a young boy, otherwise all motorcycle riders and pillion-passengers were adult, with a male/female ratio of 11 for riders and 1 for pillion-passengers. The sex ratio of the proportions each contributed to their respective total was 2 for riders and pillion-passengers combined, and 3.6 for riders alone. Two thirds of male motorcycle riders were 15-19 years old and a further 27% were aged 20-29 years. Both female pillion-passengers were aged 15-19 years and both riders were 25-29 years. The likelihood of sustaining additional injuries themselves requiring admission was higher for pillion-passengers than for riders (75% versus 38%).

Vehicle occupants were more often adults (83%) than elderly patients (8.3%) or children (8.3%). Four children were injured as rear-seat passengers and one as a front-seat passenger. One of these five had a complicated injury but none of the five elderly patients had complicated injuries. The only male patient in this latter group of five was a driver, half of the women were front and half rear-seat passengers. Vehicle occupant injuries accounted for 19% of all injuries in the elderly and 3.2% of all injuries in children, but 24% of all injuries in adults. One in six of all adult injuries occurred in car drivers who were slightly more often male than female and 54% of all injuries in car drivers were complicated, especially in men (57%) compared to women (43%). Almost one quarter of drivers were aged 20-24 years and a little over half were aged 20-34 years. The overall sex ratio among car drivers was 4. Front-seat passengers were more often women, based on the proportion of all female and male cases due to this cause. The male/female ratio of these proportions was 0.3 although the numerical ratio was 1. Complicated injuries occurred in one quarter of all front-seat passengers. More than half of this group of patients were 15-29 year olds. Rear-seat passengers were exclusively female and none had complicated injuries.

iv. Temporal Relationships:

47% of all patients with head injury who were admitted, presented to the AED between 09.00 and 17.00 hours (43% males+58% females) and 36% presented between 17.00 and midnight (39% males+28% females). The hourly distribution of both male and female patients is shown in figure 4.17. Children were more likely than adults to present during office hours, especially girls, 71% of whom attended between 09.00 and 17.00 hours compared to 56% of boys. Peaks in attendances by children occurred at 12.00-14.00 and 16.00-18.00 hours, whereas in adult males peaks occurred at 11.00-13.00, 17.00-19.00 and 23.00-01.00 hours. 43% of 15-19 year old males attended between 21.00 and 01.00 hours as did 31% of 20-24 year olds. The morning peak in adults was higher than the night-time peak, in children the early evening peak was higher than the mid-day peak. Determining a pattern in female patients was difficult owing to the small sample size, nevertheless, a late afternoon - early evening peak did occur at 16.00-18.00 hours with a further smaller rise in the late evening at 22.00-23.00 hours.

Dividing the hourly distribution into six equal four hour periods (09.00-12.59 + 13.00-16.59 etc) so as to ensure sufficient numbers in each period then the hourly distribution among admitted patients was significantly different to that among all attenders with head injury (chi-squared = 12.20, D.O.F. = 5, p less than 0.05). This difference was due largely to an over-representation of admitted patients in the periods 05.00 to 08.59, 21.00 to 00.59 and 01.00 to 04.59 and an under-representation in the period 17.00-20.59.

In both males and females the tendency was for patients with complicated injuries to present out of hours more often than patients with uncomplicated injuries. For example 42% of males with uncomplicated injury presented between 09.00 and 17.00 whereas only 38% of males with complicated injuries presented during that time. In females 59% with uncomplicated and 55% with complicated injuries presented during office hours. More marked differences were apparent when the times of out of hours attendances were

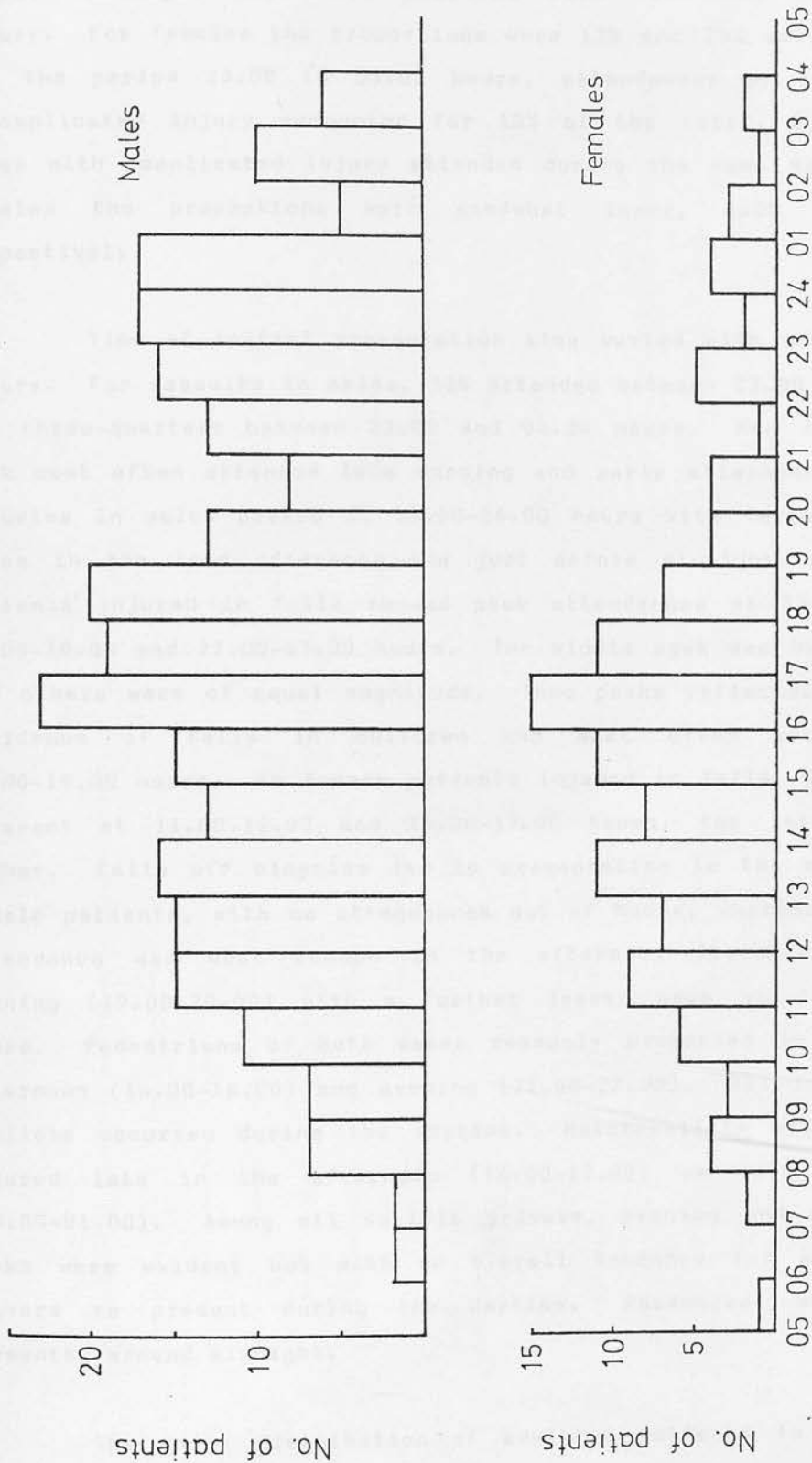


Figure 4.17 Hourly distribution of admissions 1979-1980

subdivided. Only 16% of males with uncomplicated injury attended between midnight and 09.00 compared with 30% with complicated injury. For females the proportions were 12% and 23% respectively. For the period 23.00 to 01.00 hours, attendances by males with uncomplicated injury accounted for 10% of the total, but 23% of males with complicated injury attended during the same period. In females the proportions were somewhat lower, 4.0% and 9.1% respectively.

Time of initial presentation also varied with the type of injury. For assaults in males, 38% attended between 23.00 and 01.00 and three-quarters between 23.00 and 04.00 hours. Men injured at work most often attended late morning and early afternoon. Sports injuries in males peaked at 13.00-14.00 hours with further slight rises in the late afternoon and just before midnight. In males patients injured in falls showed peak attendances at 13.00-14.00, 17.00-18.00 and 22.00-23.00 hours. The middle peak was highest and the others were of equal magnitude. Thus peaks reflected the high incidence of falls in children who most often attended at 16.00-18.00 hours. In female patients injured in falls, peaks were apparent at 11.00-12.00 and 15.00-17.00 hours, the latter being higher. Falls off bicycles led to presentation in the morning in female patients, with no attendances out of hours, whereas in males attendance was most common in the afternoon (14.00-15.00) and evening (19.00-20.00) with a further lesser peak at 21.00-22.00 hours. Pedestrians of both sexes commonly presented in the late afternoon (16.00-18.00) and evening (21.00-22.00). All injuries to cyclists occurred during the daytime. Motorcyclists were usually injured late in the afternoon (16.00-17.00) or late at night (23.00-01.00). Among all vehicle drivers, evening and night-time peaks were evident but with an overall tendency for most women drivers to present during the daytime. Passengers most often presented around midnight.

The daily distribution of admitted patients is shown in Figure 4.18. Overall, two peaks occurred, the first and lower during the middle of the week and the second and higher at the

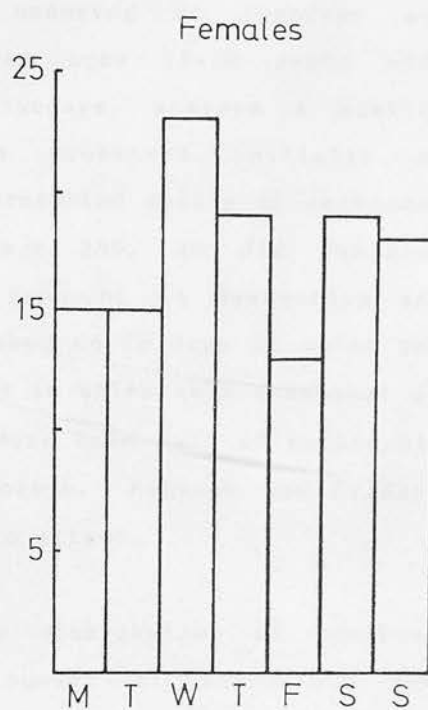
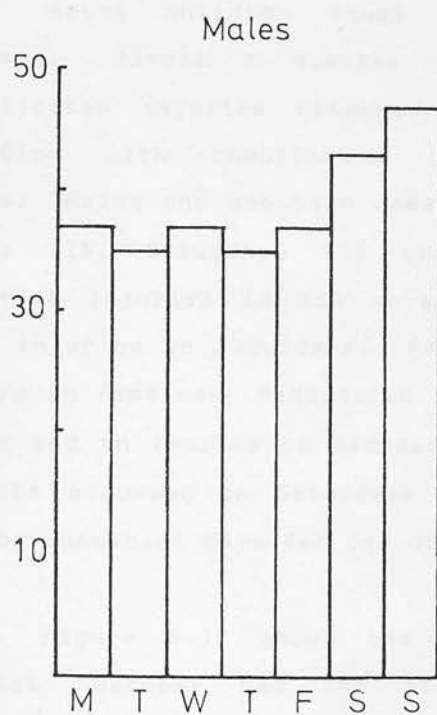
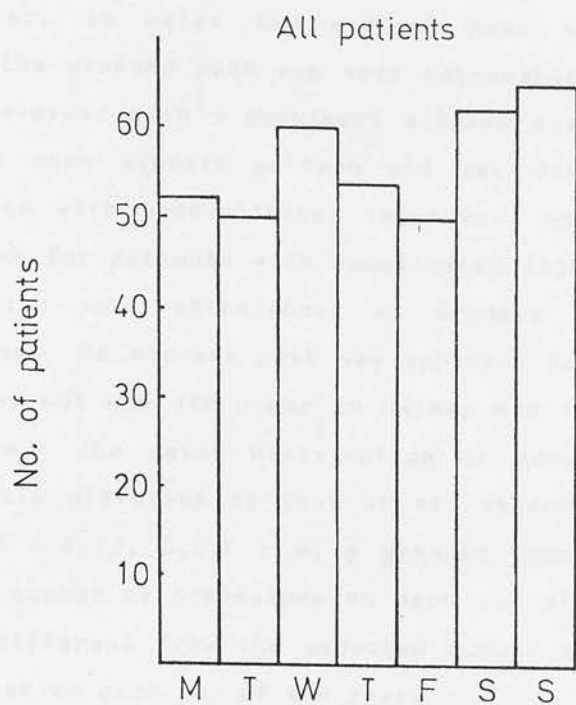


Figure 4.18 Daily distribution of admissions 1979-1980

weekend, with most patients attending on Sundays. This bimodal distribution was also seen when males and females were considered separately. However, in males the midweek peak was much less prominent whereas the weekend peak was very noticeable. In females the position was reversed with a prominent midweek peak and a lower weekend peak. The same overall pattern and sex differences were apparent in patients with uncomplicated injuries. However in both sexes the major peak for patients with complicated injuries occurred at the weekend with most attendances on Sundays in males and Saturdays in females. No midweek peak was apparent in females with complicated injuries but one did occur in males, and in both a peak occurred on Mondays. The daily distribution of admitted patients was not significantly different to that of all attenders with head injury ($\chi^2 = 4.37$, D.O.F = 6, p greater than 0.6). Using the "zI test", the number of admissions on each day of the week was not significantly different from the expected number assuming equal numbers were admitted on each day of the year.

Among children equal peaks occurred on Tuesdays and Thursdays. Almost a quarter of males aged 15-24 years with uncomplicated injuries attended on Saturdays, whereas a similar proportion with complicated injuries presented initially on Sundays. Males who had been assaulted presented mostly at weekends, Fridays 21%, Saturdays 25% and Sundays 29%, as did females. Industrial injuries in men were most frequent on Wednesdays and sports injuries on Saturdays. Falls peaked on Fridays in males and Tuesdays in females. Pedestrian injuries in males were commonest on Fridays and in females on Wednesdays. More than half of motorcycle accidents occurred on Saturdays and Sundays. Midweek and Fridays were the commonest days for car drivers to attend.

Figure 4.19 shows the monthly distribution of admitted patients. October had the highest number of admissions and generally a peak in January was followed by a smaller spring peak and then a rise in the middle and late summer continued into the autumn. A similar distribution occurred in both sexes except for a dramatic fall in female admissions during July when only three

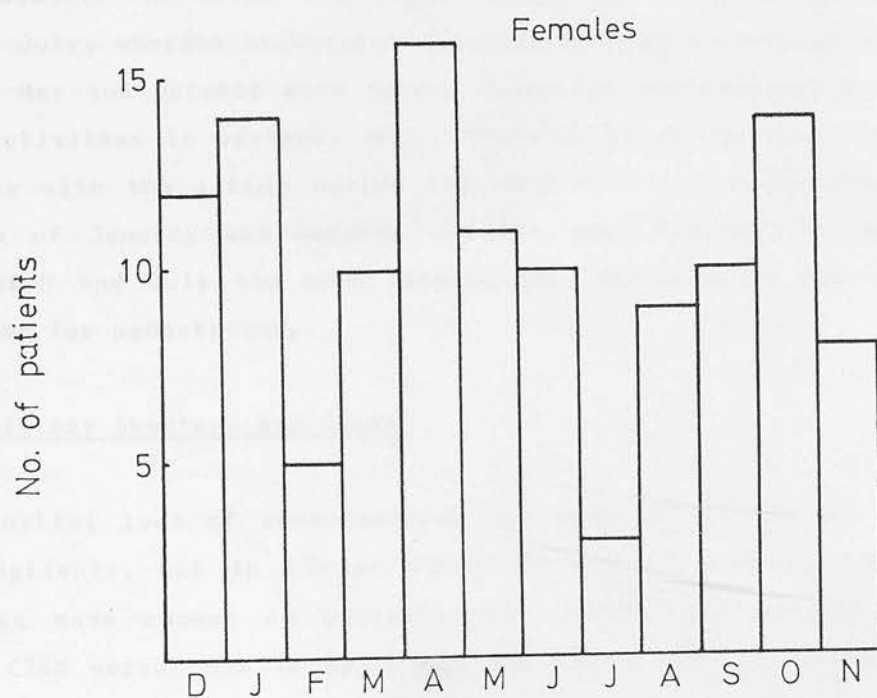
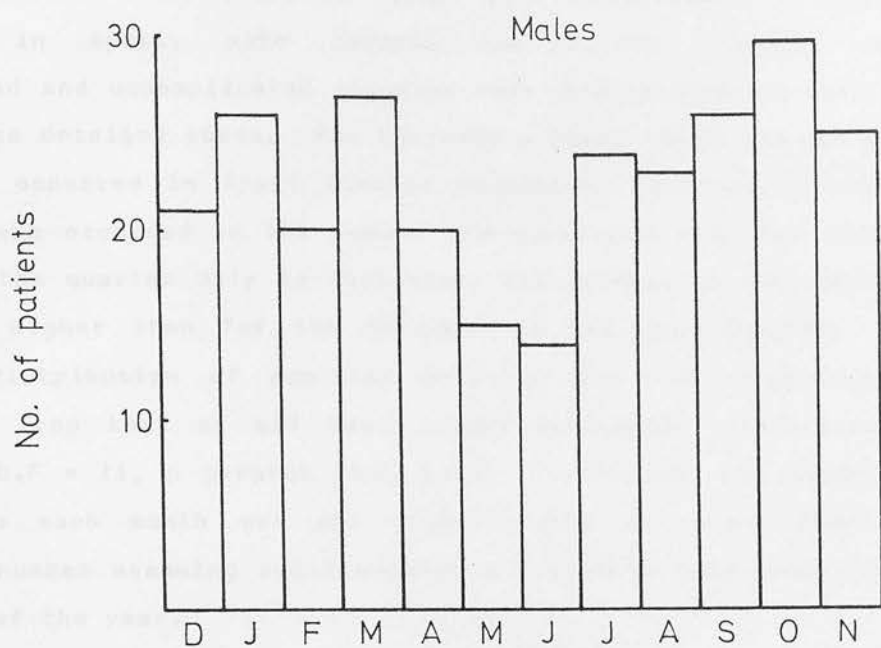


Figure 4.19 Monthly distribution of admissions 1979-1980

female patients were admitted. Also, most attendances in females occurred in April, with January and October coming next. Complicated and uncomplicated injuries were distributed in much the same way as detailed above. For children a peak, which was of short duration, occurred in April (Easter holidays), however, a broader flatter peak occurred in the summer and continued into the autumn. Thus for the quarter July to September, attendances in all children were 41% higher than for the December to February quarter. The monthly distribution of admitted patients was not significantly different from that of all head injury attenders (chi-squared = 13.68, D.O.F = 11, p greater than 0.2). Furthermore the number of admissions each month was not significantly different from the expected number assuming equal numbers of patients were admitted on each day of the year.

Assaults in males were most common in January followed closely by July, whereas industrial injuries were most often seen in December. May and October were common times for men injured during sporting activities to present, while falls in males peaked in June and October with the latter having the most cases, and in females the months of January and October had the most falls. For male drivers March and July had most attendances, compared to February and November for pedestrians.

v. History Symptoms and Signs:

Initial loss of consciousness had occurred in 60% of all admitted patients, but in 67% of males and 45% of females. This feature was more common in patients with additional reasons for admission (74% versus 65% in males and 59% versus 42% in females). A further 25% had not been rendered unconscious immediately and in the remaining 12% this fact was unrecorded. For all A&E attenders with head injury, nine hundred and ninety-seven were initially knocked out, two hundred and thirty-six of these (24%) were admitted wholly or in part because of their head injury, one hundred and seventeen (12%) were admitted because of additional injuries or conditions and not because of their head injury and the remainder

were discharged. Ten patients (0.15% of all attenders), who were initially knocked out and were sent home from the AED, reattended later and were again discharged, and six patients (0.09% of all attenders) with initial loss of consciousness who reattended were admitted. Initial loss of consciousness was least common in young children (22% of 0-4 year olds) and became more common as age increased viz 41% of 5-9 year olds and 68% of 10-14 year olds. 49% of all children and 71% of all adults initially lost consciousness, assuming patients in whom the presence or absence of this fact was unrecorded, were in fact not knocked out.

Only 44% of admitted patients who were injured in falls initially lost consciousness compared with 86% of all motorcyclists. Initial loss of consciousness also occurred in 44% of all rear-seat passengers, 52% of patients who fell off bicycles, 65% of assaults, 67% of cyclists, 73% of front-seat passengers, 78% of sport injuries, 80% of works accidents, 81% of car drivers and 83% of pedestrians.

A period of amnesia of any duration definitely occurred in 28%, was absent in 5.3% and its presence or absence was unrecorded in the remaining 66%. The relationship between amnesia and age, the cause of injury and whether additional injuries were present or not was the same as that found in relation to initial unconsciousness.

Vomiting occurred in 36% of all patients and was more common in females (42%) than males (34%). This symptom was also commoner in patients with uncomplicated injury (41%) than in patients with complicated injury (16%). Vomiting was twice as common in children (53%) as in all adults (26%), when it was also commoner in girls than boys. Consequently vomiting was more often seen in causes of injury more prevalent in childhood e.g., falls and falls off bicycles.

Early epilepsy occurred in fourteen patients - 0.2% of A&E attenders and 3.6% of head injury admissions. The male/female ratio for these cases was 7. Half of all patients were children and 43%

were aged 5-9 years. Only three patients were over thirty. Falls caused the injury in four patients (29%), falls off bicycles caused the injury in three patients (21%) and two were pedestrians.

Three fifths of admitted patients had neurological signs and these were slightly more common in females (61%) than males (59%). Signs were commoner in patients with complicated injuries (75%) than in patients with uncomplicated injuries (57%). In both sub-groups signs were commoner in females. 37% of patients definitely had no signs and in 2% either no or an inadequate CNS examination was found. Absence of signs was more common in patients with uncomplicated head injury (41%) than in patients with complicated injury (20%). Among children 57% had signs, commoner in complicated injury but equally common in boys and girls. Among adults in the working population 61% had signs; again this was commoner in cases with complicated injuries and was equally common in men (61%) and women (60%). However, among elderly patients neurological signs were much commoner, occurring in 73% of all cases but 77% of uncomplicated injuries and 69% of complicated cases. They were also commoner in females (86%) than in males (58%).

Of all A&E attenders three hundred and twenty-four had neurological signs, two hundred and thirty-six of these (73%) were admitted wholly or partly because of their head injury, forty-two (13%) were admitted because of another injury or condition alone, most being medical cases, and the remainder either took their own discharge or were sent home. In the discharged group, drowsiness had usually been present on initial examination but this disappeared subsequently and these patients were not detained.

Road traffic accidents accounted for 45% of all cases with signs, but 87% of all complicated cases with signs. In males 47% of cases with signs were due to road traffic accidents and in females 40%, and this sex difference was most marked in cases with uncomplicated injury, 37% in males and 26% in females. Subdividing traffic accidents into the various categories, signs were most common in front-seat passengers (87%) followed by motorcyclists

(79%) and then pedestrians, cyclists and drivers all 75% and finally rear-seat passengers (67%). Among non-traffic accidents the incidence of signs was lowest in cases of assault (50%) and highest in industrial injuries (53%) with falls, sports accidents and falls off bicycles all showing a 52% incidence. No sex differences existed in cases of assault and no women were admitted as a result of industrial injuries, but for sports accidents three out of four women had neurological signs compared with eight of seventeen men. Injuries resulting from falls produced signs in 59% of females and 48% of males, whereas falls off bikes produced signs in 59% of males and only 38% of females. Signs occurred in 76% of male and 73% of female pedestrians, but in all female and two-thirds of male cyclists. Similarly all female and 76% of male motorcyclists had neurological signs. Signs were commoner in male drivers (76% versus 71%), female front-seat passengers (75% versus 71%) and male rear-seat passengers (100% versus 57%).

vi. Plain X-Ray:

A radiologically apparent skull fracture was present in one hundred and three admitted patients (26%) and was equally common in both sexes. Twenty-eight of these fractures had also been identified clinically. Fractures were present in 27% of children, 25% of adults and 31% of elderly patients. They were equally common in children of either sex, but slightly more common in adult females (27%) than in adult males (25%) and twice as common in elderly men (42%) as in elderly women (21%).

A further twenty-one patients had fractures clinically but not radiologically, twenty of these patients were male (6 children and 14 adults) and one was an adult female. Altogether therefore, one hundred and twenty-four patients had fractures either radiologically or clinically; 38% were children, 55% were adults and 6.4% were elderly patients. Overall such fractures were commoner in males (34%) than females (27%) and this applied to all three age groups, but particularly to elderly patients. The incidence was almost equal in patients with complicated (30%) and uncomplicated

(32%) injuries. However in the former group, fractures were more common in females (32% versus 29%) and in the latter were more common in males (35% versus 26%). Traffic accidents were responsible for 40% of all fractures but 81% of skull fractures in patients with complicated injury. On the other hand, falls produced 27% of all fractures but only 4.8% of fractures in patients with complicated injuries. Furthermore falls were responsible for 27% of fractures in both females and males, and road accidents for 42% and 39% respectively. This discrepancy arose because assaults and accidents at work were not responsible for any skull fractures in females but caused 15% of fractures in males. Among the victims of traffic accidents, fractures were most common in cyclists (58%), followed by pedestrians (44%) and least common in rear-seat passengers (22%) with motorcyclists (31%), drivers (31%) and front-seat passengers (33%) intermediate. Industrial accidents (40%) were the commonest cause of fractures in patients not injured in traffic accidents and sports injuries (14%) were least likely to produce fractures in this group. Falls from bicycles (36%), assaults (31%) and falls (27%) were intermediate in their likelihood of producing a fracture.

Almost two-thirds of cases with clinically and/or radiologically identified fractures in females presented between 09.00 and 17.00 hours compared with only 41% in males. More than one quarter of male patients with fractures presented between 17.00 and 20.00 hours compared with 18% of females. 3.0% of female patients with fractures attended between 22.00 and 02.00 hours compared with 17% of males. In females most patients with fractures presented on Thursdays whereas in males equally high numbers attended on Thursdays and Sundays. March (11) and October (14) had the highest number of male patients with fractures and January (6) and April (6) the highest number of females. The overall incidence during the July to September quarter was only marginally higher than during the December to February quarter.

vii. Reasons For Admission:

Three broad categories of admission were recognised:

- a) Admitted because of head injury alone 324
- b) Admitted because of head injury and another injury/condition 69
- c) Admitted because of another injury/condition alone 327

Patients in groups a + b have already been characterised in sections i-vi above. Table 4.11 shows the reason for admission according to sex for each of the three categories. The commonest

REASON FOR ADMISSION	HEAD INJURY ONLY			HEAD INJURY & OTHER			OTHER ONLY		
n=	M	F	ALL	M	F	ALL	M	F	ALL
	224	100	324	47	22	69	194	133	327
SYMPTOMS	56	36	92	2	3	5			
? FRACTURE	23	17	40	6	1	7			
FRACTURE	78	26	104	14	7	21			
SIGNS	127	58	185	38	17	55			
FIT	11	2	13	1	0	1			
SURGICAL				19	11	30	56	23	79
ORTHOPAEDIC				20	13	33	65	59	124
OPHTHALMIC				1	0	1	23	7	30
ENT				1	0	1	4	2	6
DENTAL				6	1	7	5	5	10
MEDICAL				1	1	2	24	24	48
GERIATRIC				1	0	1	9	10	19
OTHER				5	2	7	21	15	36
ALL REASONS	295	139	434	115	56	171	207	145	352

Table 4.11 Reasons for admission in the three broad groups.

reason for admission in the head-injured group (a+b) was the presence of neurological signs, which occurred in 61% and was almost equally common in males and females, but more common in patients in group b. For patients admitted because of head injury alone there were 1.3 reasons for admission per patient (1.4 for females and 1.3 for males). For patients with dual reasons for admission there were 2.5 reasons for admission per patient (2.5 for females and 2.4 for males), and for 'other only' 1.1 reason per patient (1.1 for males

and females). These results suggest that multiple reasons for admission were most often related to the head injury alone and few patients had more than two reasons for admission. Among patients in group b, trauma other than to the head accounted for 88% of the non-head injury reasons for admission. Traffic accidents accounted for 83% of the surgical and 94% of the orthopaedic reasons for admission in these patients. Car drivers, especially men, were particularly likely to have general surgical problems requiring admission in addition to their head injury. Pedestrians, drivers and motorcyclists were most likely to have additional orthopaedic problems meriting admission in their own right. The only eye injury requiring admission in its own right occurred in a male driver, whilst facio-maxillary injuries were confined to drivers and motorcyclists. The small number of patients with additional medical or geriatric reasons for admission were all injured in falls precipitated by a 'collapse'.

Among patients admitted because of other injuries or conditions alone, general surgical and orthopaedic trauma together with injuries to the eyes and facial skeleton accounted for 71% of the total number of reasons for admission. Traffic accidents contributed the bulk of general surgical (78%) and orthopaedic (64%) reasons for admission. Drivers, other vehicle occupants of either sex and male motorcyclists were those most likely to have general surgical problems, whereas these same groups together with pedestrians accounted for most orthopaedic problems. In addition falls were responsible for about a quarter of orthopaedic reasons for admission. 84% of medical and geriatric problems leading to admission occurred in patients who had fallen or collapsed. More than a quarter of eye injuries resulted from sports accidents, assaults and vehicle occupants each accounted for a further one in five cases.

For all surgical reasons (groups b + c) 17% presented between 23.00 and 01.00 hours and 21% between 17.00 and 20.00 hours, compared to 8.9% and 22% respectively of orthopaedic reasons and 7.1% and 16% of medical and geriatric reasons. A little over a

third of patients with surgical reasons for admission attended at weekends with more males on Sundays and more females on Saturdays. A similar proportion of patients with orthopaedic problems were seen at weekends. In males one third of surgical problems presented in March and April and almost one fifth of females presented in September. This latter month was the commonest month for males with orthopaedic problems to present, with December next commonest, whereas in females January was commonest and September next.

viii. Treatment:

Intravenous infusions were required in one hundred and twenty-three admitted patients (17%). Haemaccel or other plasma expander was administered in twenty-two patients and blood in thirty-eight patients, some having both. A skull fracture was present in twenty-five patients (20%) and neurological signs in 44%. Early epilepsy occurred in two patients. General surgical problems themselves meriting admission occurred in 47% and orthopaedic problems in 41%, some cases having both. Medical and geriatric conditions were present in only seven cases (3.3%). For patients who were given blood, the incidence of fractures (21%), signs (50%), orthopaedic problems (66%) and surgical problems (68%) was higher. No medical patients were given blood transfusions or plasma expanders.

Only five patients needed insertion of a chest drain, either on one or both sides. One of these five patients had a skull fracture and two had neurological signs. However, five patients had surgical and four patients had orthopaedic problems warranting admission in their own right. In contrast nearly four times as many patients required endo-tracheal intubation. Eight of these nineteen cases had skull fractures, fifteen had neurological signs and one had early epilepsy. General surgical problems existed in seven cases and the same number had orthopaedic injuries necessitating admission. Two patients had general medical conditions.

Peritoneal lavage was performed on thirteen occasions,

three cases having skull fracture and five having neurological signs. All of these patients had general surgical problems meriting admission and eight had orthopaedic problems.

Only eight patients had dexamethasone, all were male and all had neurological signs on admission. Six of these patients had skull fractures, one had early epilepsy and one had additional orthopaedic injuries. Mannitol was administered to four patients again all were male. All four had skull fractures and neurological signs.

One hundred and twelve patients underwent procedures under general anaesthesia. Skull fractures were present in twelve patients and eighteen had had neurological signs on presentation. One patient had experienced early epilepsy. General surgical injuries were present in twenty patients (18%), orthopaedic problems in 62% and ophthalmic injuries in 8%. A small proportion of these patients were treated as out-patients, i.e., had general anaesthetics in the AED and were subsequently discharged. Bier's block was introduced by the accident staff before the start of the prospective study and was freely used for patients of about ten years or above with upper or lower limb injuries.

Altogether thirty-eight patients were admitted to the intensive care unit, twenty-seven males and eleven females. Seven patients were children (male/female ratio 6:1), only one (female) patient was over sixty-four years old. Nine patients were aged 15-24 years (male/female ratio 8:1) and twelve were aged 45-54 years (male/female ratio 1:1). Twenty-eight patients (74%) had been injured in road traffic accidents: nine motorcyclists, seven drivers, four pedestrians, four front-seat passengers, two cyclists and two rear-seat passengers. The male/female ratio for traffic accidents was 2.1 and for non-traffic accidents was 4.0. Initial loss of consciousness had occurred in thirty-one cases, twenty-six had signs and seventeen had skull fractures, but only four had early epilepsy. Fourteen patients (37%) subsequently died.

ix. Length of Stay:

The cumulative percentage discharges for each of the three broad categories of patients are shown in Figure 4.20. For patients with head injury only, 38% were discharged by the end of the first day and 63% by the end of forty-eight hours. One in ten patients remained longer than one week and 2.8% longer than one month, less than 1% staying beyond two months. More women were discharged during the first two days than were men and slightly more women stayed longer than seventy-two hours, but they were all discharged within six weeks. However, nearly 1% of males stayed for longer than six weeks. Children stayed for less time, no girls and only two boys were admitted for longer than ten days. 49% of children were discharged by the end of twenty-four hours and three-quarters within the first two days. In contrast, no men over sixty-four years old stayed less than two weeks whereas no elderly women stayed longer than three weeks. Sample sizes in the older age groups were small. No patient injured in an assault or at work stayed longer than ten days and only two patients injured during a sporting activity stayed beyond forty-eight hours. Almost half of those injured in falls were home again within twenty-four hours and 72% within forty-eight hours. Patients injured in traffic accidents stayed longer than other cases and 55% of all patients staying in hospital for ten days or more were the victims of traffic accidents.

For patients admitted because of a head injury and another injury or condition, only 17% were discharged by the end of the first day and one quarter by the end of the second day. More than half stayed longer than one week and almost one fifth stayed longer than one month, but only 6% stayed beyond three months. More males than females were discharged in the first three days, but by one week half of all females and 46% of all males had been discharged. Thereafter males were discharged sooner than females - after one month 15% of males and 27% of females were still in hospital. Sample sizes were small in this group of patients, however, there was an overall tendency for elderly patients to stay for more than two weeks and for young adults to stay less than two weeks. No

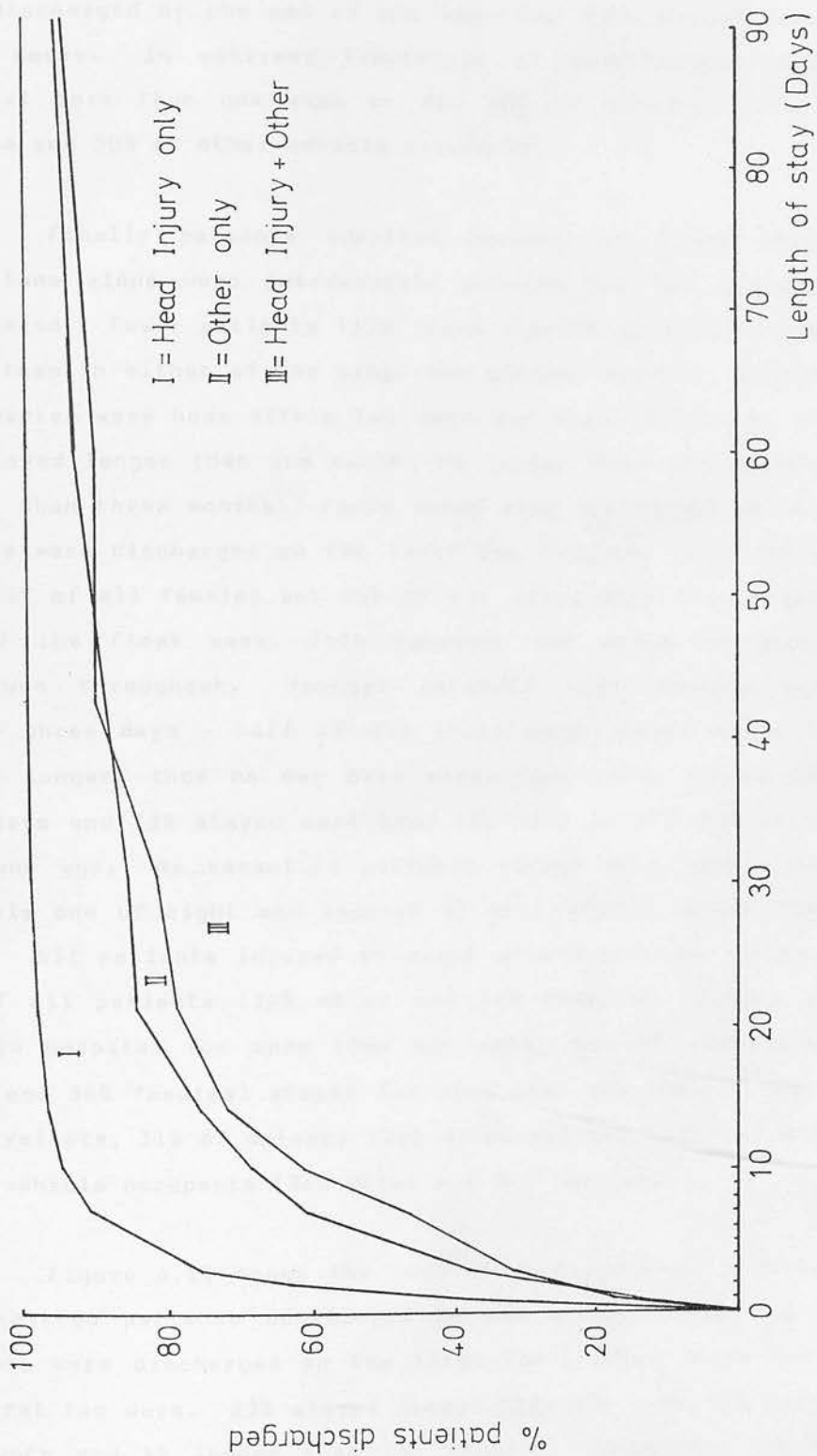


Figure 4.20 Cumulative percentage discharges of the 3 groups of patients

patients assaulted, injured at work or during sporting activities stayed beyond two weeks. Two thirds of patients injured in falls were discharged by the end of one week and none stayed longer than three weeks. In contrast two-thirds of pedestrians remained in hospital more than one week as did 58% of motorcyclists, 65% of drivers and 50% of other vehicle occupants.

Finally patients admitted because of other injuries or conditions alone were intermediate between the two groups already considered. Fewer patients (15%) were discharged within twenty-four hours than in either of the other two groups, however, a little over one quarter were home within two days and three fifths by one week. 15% stayed longer than one month, 8% longer than two months and 5% longer than three months. Fewer women were discharged early, 11% of females were discharged on the first day compared with 17% of males and half of all females but 68% of all males were discharged by the end of the first week. This tendency for women to stay longer continued throughout. Younger patients were usually discharged within three days - half of all 10-24 year olds. Older patients stayed longer, thus no men over sixty-nine years stayed less than four days and 72% stayed more than ten days as did 59% of women of the same age. No assaulted patients stayed more than three weeks and only one of eight men injured at work stayed longer than three weeks. All patients injured at sport were discharged by two weeks, 57% of all patients (30% males and 54% females) injured in falls were in hospital for more than one week, 43% of pedestrians (50% males and 38% females) stayed for more than one week as did 49% of motorcyclists, 31% of drivers (22% males and 64% females) and 49% of other vehicle occupants (36% males and 54% females).

Figure 4.21 shows the cumulative percentage discharges for all admitted patients considered as one group. Only one in four patients were discharged in the first twenty-four hours and 43% in the first two days. 23% stayed longer than one week, 9% longer than one month and 5% longer than two months. Throughout, consistently fewer females were discharged at each time interval. Children were discharged more quickly and older patients less quickly. Cases

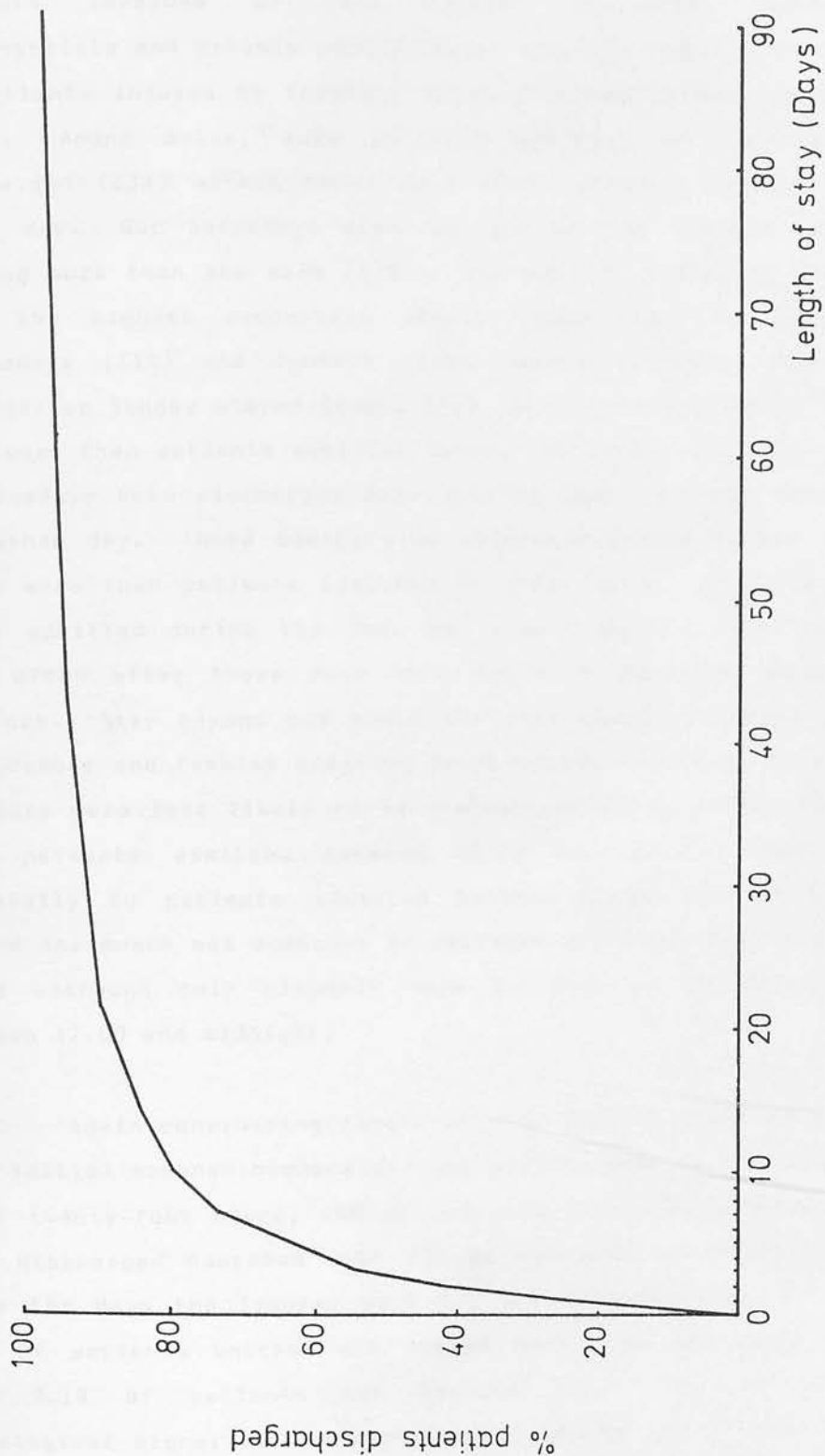


Figure 4.21 Cumulative percentage discharges of all admitted patients

injured in non-traffic accidents were discharged more quickly than patients involved in road traffic accidents, pedestrians, motorcyclists and drivers particularly, staying longer. In the case of patients injured by falling, females tended to stay longer than males. Among males, more patients admitted on Saturdays were discharged (63%) within three days than patients admitted on any other day. But Saturdays also had one of the highest proportion staying more than one week (27%). The days of admission associated with the highest proportion staying more than one month were Wednesdays (11%) and Sundays (11%). Female patients admitted on Saturday or Sunday stayed longer than three days and longer than one week more than patients admitted during the week. Patients admitted on Tuesdays were discharged more rapidly than patients admitted on any other day. Those admitted on Saturdays stayed longer than one month more than patients admitted on other days. Patients of both sexes admitted during the June to August quarter were discharged more often after three days than patients admitted during other quarters. Stay beyond one month was most common in males admitted in December and females admitted in November. Patients admitted out of hours were less likely to be discharged within twenty-four hours than patients admitted between 09.00 and 17.00, this applied especially to patients admitted between 24.00 and 09.00. Stay beyond one month was commoner in patients admitted between 09.00 and 17.00 although only slightly more so than in patients admitted between 17.00 and midnight.

Again considering length of stay for all admitted patients, then initial unconsciousness did not prolong stay in the short term. After twenty-four hours, 28% of patients initially knocked out had been discharged compared with 23% of patients not knocked out and after two days the figures were 47% and 39% respectively. However 9.7% of patients knocked out stayed more than one month compared with 9.1% of patients not knocked out. For patients with neurological signs, 31% were discharged by the end of the first day compared with 21% of patients without signs, by three days the proportions were 60% and 49% respectively. The proportions staying more than one month were 9.7% for patients with signs and 9.2% for

patients without signs. These and other variations in the period of time spent in hospital are reflected in Table 4.12, which shows the approximate median duration of stay in groups with various characteristics. Not unexpectedly orthopaedic and geriatric patients have the longest duration of stay. In addition the approximate median duration of stay for all males was 2-3 days and for all females 4-7 days.

REASON FOR ADMISSION	APPROXIMATE MEDIAN DURATION OF STAY
ALL ADMISSIONS	2-3 days
HEAD INJURY ONLY	1-2 days
HEAD INJURY & OTHER	8-10 days
OTHER ONLY	4-7 days
(KNOCKED OUT)	2-3 days
(AMNESIC)	2-3 days
VOMITED	1-2 days
EXCESS SYMPTOMS	1 day or less
SKULL FRACTURE	4-7 days
NEUROLOGICAL SIGNS	1-2 days
SURGICAL	4-7 days
ORTHOPAEDIC	8-10 days
MEDICAL	4-7 days
GERIATRIC	15-21 days
RTA	4-7 days

Table 4.12 Approximate median duration of stay 1979-1980.

Because of the irregular time intervals used only an approximation of the number of bed-days used could be determined. Thus all admissions accounted for 7742 bed-days or an average of 10.8 per patient. For patients with head injury only the total was 1384 (4.3/patient). For patients with head injury and other it was 1259 (18.2/patient) and for patients with other injuries or condition alone was 5099 (15.6/patient). For all head-injured patients 2643 bed-days were occupied at an average of 6.7 bed-days per patient. These represented 5.9% of all available general surgical bed - days but 13% of all emergency general surgical admissions.

4.2.5 Neurosurgical Events:

Ten (8.5%) of the one hundred and seventeen patients with a fracture on skull X-ray had depressed fractures and half were also diagnosed clinically. One additional patient had a compound depressed frontal fracture identified clinically although skull X-rays were negative. Ten of the eleven depressed fractures were compound. Only two patients with depressed fractures were female (male/female ratio 4.5), three patients including one girl were children aged six, seven and ten years, three more were aged seventeen, eighteen and nineteen years, two more twenty and twenty-four years and the remaining patients were aged thirty-seven, fifty-six and sixty-nine years. The latter patient was the other woman. Five patients had been injured in road traffic accidents - one cyclist, two drivers, one front-seat and one rear-seat passenger. The six year old boy had been struck with a golf club, a further patient had been struck with a bottle and another was hit by falling metal at work. One ten year old boy fell off a skateboard and a twenty year old man was injured playing football and had a closed depressed fracture. Six of the patients had simple suturing without elevation of the fracture and only one of these six cases was sutured in theatre. Later on the day of admission one of the above six patients was transferred to the regional neurosurgical unit where the depressed fragment and dead tissue and hair incorporated beneath the sutured laceration were removed. Five of the eleven patients, including the patient with a closed fracture, were immediately transferred to the regional neurosurgical unit where surgical debridement and elevation of the fracture was performed. Two of these five patients had extradural haematomas and a further patient from this group had an intracerebral haematoma. None of the eleven cases died, one developed anosmia, the patient with an intracerebral haematoma was transferred to long term institutional care, a further patient had mild monoparesis of the left upper limb together with bilateral upper motor neurone lesions of the seventh cranial nerve. The remaining eight patients suffered no permanent sequelae.

Fourteen patients were transferred to the regional neurosurgical unit, representing 3.6% of admitted patients but only 0.2% of all attenders. Six of these, with depressed fractures and already referred to above, were all transferred during the first twenty-four hours. Five of the remaining eight patients were transferred primarily because of an abnormal conscious level, some also having other signs. An additional patient was transferred because of persistent ataxia. Finally, the two remaining patients were transferred because of symptoms, one also having minimal neurological signs. These latter two patients were transferred from the medical wards, neither gave any history of head injury and neither had attended the AED during the course of their illness. However, both patients were subsequently shown to have a chronic subdural haematoma and they have been included as head-injured patients. Excluding these two patients and those with depressed fractures already mentioned, three patients were transferred during the first twenty-four hours and the remainder twenty-four days, twenty-five days and four months after injury. All transferred patients underwent CT examination. As well as the two patients already referred to, an additional transferred patient had a subdural haematoma. This eighty-one year old sustained a head injury as a result of a fall and was admitted to a general surgical ward for four days. Eleven days after her discharge she was re-admitted under the care of the Geriatricians because she was drowsy and had a fluctuating level of consciousness. A brain scan in Chester, nineteen days after injury, revealed a subdural haematoma, confirmed five days later by CT scan. Operation was refused and the patient died seven weeks after her injury. Gross hydrocephalus was revealed during the course of investigation of another patient four months following injury. Subsequent decompression of the posterior cranial fossa showed scarring resulting from an operation in childhood. Another elderly patient was suspected of having a subdural haematoma, CT scan was negative and further enquiry revealed his symptoms had preceded his injury by upto five years and a diagnosis of senile dementia was made. This patient died four months following his initial admission, the cause of death was given as bronchopneumonia and no post-mortem was

performed. The three remaining patients all had cerebral oedema and/or contusions on CT scan, none had mass lesions and all three died. Post-mortem examination in these latter three cases confirmed the absence of mass lesions.

As well as the patients referred to above, five patients were operated on in Chester because of dramatic deterioration in their conscious level. In two of these cases no clot was found although one patient had a dural laceration. An eleven year old boy had a temporo-parietal extradural haematoma evacuated and made a complete recovery. A twenty year old motorcyclist had temporal extradural and subdural haematomas evacuated but died four days later. Finally, a forty year old man injured in a fall at work underwent operation for evacuation of acute subdural and intracerebral haematomas. Unfortunately he died thirty-six hours later. A large intracerebral haematoma ipsilateral to the subdural haematoma was found at post-mortem.

In addition to the post-mortem findings described above a forty-nine year old male front-seat passenger, who died thirty-seven hours after injury and was unconscious throughout, was found to have a large extradural haematoma at post-mortem, as well as a basal fracture and severe cerebral contusions ipsilateral to the haematoma. A ninety year old man, dead on arrival and known to have been taking Warfarin, had ipsilateral subdural and intracerebral haematomas at post-mortem. Post-traumatic intracranial haematomas thus occurred in eleven patients, with a total of fourteen haematomas being found, four acute extradural haematomas (EDH) alone, one acute extradural haematoma accompanied by an acute subdural haematoma (SDH), two acute subdural haematomas both accompanied by intracerebral haematomas (ICH), one acute intracerebral haematoma, one subacute subdural haematoma and two chronic subdural haematomas. The incidence of the various types of haematoma was thus:

Acute EDH	5 cases	13/1000 admissions	19.0/1,000,000 pop
Acute ICH	3 cases	7.6/1000 admissions	11.4/1,000,000 pop

Acute SDH	3 cases	7.6/1000 admissions	11.4/1,000,000 pop
Chronic SDH	2 cases	5.1/1000 admissions	7.6/1,000,000 pop
Subacute SDH	1 case	2.5/1000 admissions	3.8/1,000,000 pop

Other sequelae of head injury observed in this series are summarised in Table 4.13. Some patients had more than one complaint. Seven of the patients who developed early epilepsy had clinical and/or radiological evidence of skull fracture, a further patient had a fracture clinically (and also at post-mortem). Nineteen of the twenty-five patients were male, 36% were children and one-fifth were over sixty-four years old.

EARLY EPILEPSY	25
ANOSMIA	4
VIII NERVE DEAFNESS	4
OTHER CRANIAL NERVE LESIONS	5
HEMIPARESIS/PLEGIA	3
MONOPARESIS/PLEGIA	2
INTRACRANIAL AIR	2
TRANSITORY DIABETES INSIPIDUS	1

Table 4.13 Neurosurgical events 1979-1980.

4.2.6 Mortality:

Eighty-eight patients died, thirty-six being brought in dead (BID). Post-mortem examination was refused in one patient who was known from CT scan to have recurrent subdural haematoma. In a further seventeen patients, including three of those brought in dead, no post-mortem was performed. All seventeen patients were certified as dying from medical causes - six from myocardial infarction, six from bronchopneumonia, three from cardiac failure and two from cerebro-vascular accidents. None of these patients had significant head injuries. Medical causes accounted for the deaths of an additional eight patients from among the seventy patients who underwent post-mortem examination. Five had suffered myocardial infarction, one epileptic died from asphyxia having fallen on his face during a convulsion, one patient died from rupture of a dissecting aneurysm of the thoracic aorta and one patient died as a result of gastro-intestinal haemorrhage due to carcinoma of the stomach. The remaining sixty-two patients all died as a result of trauma. Sixteen died primarily from chest injury and six of these were brought in dead. Four late deaths were due to bronchopneumonia and occurred ten, fifteen, twenty and forty-six days after injury and one late death after forty-two days resulted from gangrene of the bowel. The five remaining patients died early from chest and/or abdominal injuries. None of these sixteen trauma deaths was associated with any abnormality of the skull or brain, although one patient had a fracture of the nasal bones. Thus forty-six patients undergoing post-mortem examination did have macroscopic abnormalities of the skull and/or brain. To these can be added the patient with recurrent subdural haematoma making a total of forty-seven head injury deaths, twenty-three brought in dead and twenty-four dying later. These head injury deaths will now be reported in detail.

a) Incidence, Age and Sex:

Death due to head injury occurred in 0.7% of A&E attenders, whereas the hospital case-fatality rate was 6.1%, if two patients

dying in the AED are included and twenty-three brought in dead are excluded from the calculation. The overall mortality rate was 18/100,000 for all cases irrespective of the time of death, 28/100,000 for males and 8.1/100,000 for females. In males the mortality rate varied from 17/100,000 in children to 29/100,000 in adults aged 15-64 years and 43/100,000 in elderly men. However the rate in 15-19 year old men was 85/100,000. The rates in females were lower, varying from nil for girls upto fourteen years old, 7/100,000 for women aged between 15-64 years and 24/100,000 for women over sixty-four years old. In 15-19 year old women the rate was 19/100,000.

The male/female ratio for all deaths was 3.3 (2.8 for BID's and 3.8 for later deaths). The age range was two months to ninety years, although no girls under fifteen years of age died. The median age was thirty-five years (20 years for males and 62 years for females). 55% of deaths in females occurred in women aged sixty years or more compared with 19% of males. 28% of males and 18% of females who died were aged 15-19 years and 42% of males dying were aged 15-29 years. Of all deaths, 11% were children - all boys, 66% were aged 15-64 years and 23% were over sixty-four years old.

b) Predispositions and Associations:

Blood alcohol estimations were performed in thirteen of those brought in dead (59% of those 15 years or older) but in only three of those dying later (15% of those 15 years or older). Five of the patients tested had no alcohol detected, four more had a level below 20mg%, the remaining patients had levels of 120, 128, 190, 210, 214, 220 and 307 mg%. Nearly half of all patients tested had a blood alcohol level greater than the legal limit for driving, the highest being almost four times this limit. Four were injured in falls (120, 128, 190 + 214 mg%), one was a pedestrian (210 mg%), one a motorcycle rider (220 mg%) and one a car driver (307 mg%), only one of the patients with such high levels was a woman and only two of the eleven patients with any detectable alcohol were women.

One patient, brought in dead and presumed to have fallen at home, was ninety years old and had a large intracerebral haematoma and a subdural haematoma but no skull fracture. The patient was known to have been taking Warfarin, which, together with his age, would have predisposed him to developing subdural bleeding. Another patient with a chronic subdural haematoma, whose relatives refused operation, was known to suffer vertebro-basilar transient ischaemic attacks producing numerous falls. Finally, the patient with recurrent subdural haematoma, in whom post-mortem was refused, had suffered an episode of lobar pneumonia shortly before presentation. Although this lady had a six month history of headache, it was thought possible that coughing associated with her chest infection might have been of aetiological significance.

c) Causes:

Traffic accidents accounted for 17% of all A&E attenders with head injury and 35% of admitted head injuries, but 81% of head injury deaths. Twenty of these thirty-eight traffic deaths occurred before the patients reached hospital. Road traffic accident deaths were commoner in males (86% of male deaths) than in females (64% of female deaths). Breakdown of the deaths resulting from road traffic accidents was as follows - fourteen pedestrians, ten motorcyclists, six front-seat passengers, three car drivers, three cyclists, one pillion-passenger and one rear-seat passenger. Thirty-one patients were male (male/female ratio 4.4). Six of the seven females were pedestrians and two thirds of them were over forty years old, the other two patients being fifteen and sixteen years old respectively. Death occurred prior to arrival at hospital in two thirds of female pedestrians. Half of the eight male pedestrians were aged fifty-five or more, the others being nine, ten, twelve and eighteen years. Only one quarter of male pedestrians were dead on arrival. Motorcycle riders accounted for 28% of all male deaths and three fifths of them were brought in dead. Seven of the ten were aged 17-20 years and the oldest was thirty-five. The only female motorcyclist injured was a forty-five year old pillion-passenger who was dead on arrival at hospital. One male motorcyclist had a blood

alcohol of 220mg% and was also dead on arrival. Three further cases had no detectable alcohol level and three more had levels up to 20mg%.

All three cyclists were male, two were seventeen year olds and the other was sixty years old. One of the former was dead on arrival and had no detectable blood alcohol.

Two of the three car drivers, both males, were dead on arrival and were aged eighteen and twenty. The latter had a blood alcohol of 307 mg% and had not been wearing a seat belt, while the former had a level of 20mg%. The third driver was twenty years old and was admitted at 11.00 hours, alcohol was not thought to be implicated in his death. He had been wearing a seat belt.

Half of the six front-seat passengers died after arriving at the hospital. All six were male and were aged nineteen, thirty-five and seventy (BID's) and two months, forty-three and forty-nine years. Five of these patients had not been wearing seat belts, the only one who had was a seventy year old man who was dead on arrival. None of these patients had blood alcohol estimations. The only rear-seat passenger killed was a three year old boy.

Non-traffic accidents accounted for nine deaths, all resulting from falls and five patients were male (male/female ratio 1.3). Two men and one woman were dead on arrival. One of the men who died later had fallen at work, another, a railway employee, fell on his way home as he was crossing a railway track and was struck and trapped by a slow moving train. He had a blood alcohol of 214 mg%. The remaining patients had all fallen at home, three of them falling downstairs. The age range of these nine patients was 39-90 years with a median age of sixty-two years. Four patients had blood alcohol measurements, including one seventy year old woman and the results were 120, 128 (the woman), 190 and 214mg%. One elderly man had been taking Warfarin and had both subdural and intracerebral haematomas on the contralateral side to his scalp contusion. One elderly woman had a long history of vertebro-basilar transient

ischaemic attacks with numerous falls and also had a subdural haematoma.

d) Temporal Relationships:

Overall, Fridays (10 deaths) and Saturdays (8 deaths) were the commonest days of attendance for patients who died. Wednesdays were also associated with a high number of deaths (8). Almost half of those killed as the result of falls presented on Saturdays and a further quarter on Fridays. Fourteen pedestrians were killed, four presented on Fridays, three on Saturdays and three on Thursdays. Almost one in three motorcyclists first attended on Sundays. Vehicle occupants also presented more often towards the end of the week. Every day of the week had at least two fatalities from traffic accidents and at least three fatalities from any cause.

Most deaths occurred in the summer, followed by the winter. Seven deaths occurred in July and six in January. Four of the fourteen pedestrians were injured in January, three in March, two each in April, August and October and one in July. Motorcycle deaths occurred more often in late summer/early autumn and late spring/early summer, five of the eleven deaths occurred from April to June and a further five from August to October. Vehicle occupants were killed more often in late winter/spring and in summer.

The hourly distribution of attendance by patients who subsequently died showed three peaks: early morning, early evening and late at night. Twenty deaths occurred in patients presenting between 09.00 and 17.00 hours, and seventeen deaths in patients presenting between 17.00 and 01.00. Six of the fourteen pedestrians, including all three children, presented between 16.00 and 20.00 hours, whereas four of the ten vehicle occupants presented between 22.00 and 02.00. Deaths resulting from non-traffic accidents were randomly distributed throughout the twenty-four hours.

e) Time to Die:

Twenty-three patients (49%) died prior to their arrival at hospital and this was more common in patients injured in road traffic accidents (53%) than in others (33%). A further two patients were dead by the end of the first hour after arriving at the AED, four more by the end of six hours and seven more by the end of the first day. Thus after six hours 62% of deaths had already occurred and by the end of the first day 77% of deaths had taken place. Two more patients died during the second twenty-four hours, one on the third day, two on the fifth day and one on the sixth day. By the end of the first week 89% of all deaths had occurred. Three patients died during the second week, one more after thirty days and the longest survivor died after forty-nine days.

One third of all patients injured in falls, one third of cyclists, 43% of pedestrians, 50% of front-seat passengers, 60% of motorcyclists, 67% of drivers and the only pillion and rear-seat passengers were dead on arrival. By the end of the first day 64% of pedestrians, 90% of motorcyclists and all three cyclists had died. The longest surviving pedestrian died two weeks and the longest surviving motorcyclist nearly five days after injury. Of those patients alive on arrival at hospital two thirds of front-seat passengers and half of motorcyclists were dead within three hours and three quarters by fifteen hours, whereas three of the eight pedestrians were dead within twenty-two hours.

Six patients injured in falls were alive on arrival at the AED. One third died within nine hours, one half within twenty-four hours and two thirds within thirty-seven hours, the remaining two dying after thirty and forty-nine days respectively. The median time to death for this group was eight hours and eleven minutes from arrival at hospital. For all road traffic accident victims the median time to death was unknown since twenty of the thirty-eight deaths occurred prior to arrival at the AED, but must have been less than one hour. For pedestrians only the median time to death was twelve hours and thirty-three minutes. Considering only those patients alive on arrival at hospital the median times to death were: 2.1 hours (front-seat passengers) 8.6 hours (motorcyclists)

11.6 hours (cyclists), 28 hours (falls) and 6.1 days (pedestrians).

f) Post-Mortem Findings:

1. Skull Fractures:

Thirty-one patients (66%) had a skull fracture, eight were vault fractures, fifteen basal fractures and eight combined fractures of the vault and base. An additional patient did not have a fracture found at post-mortem but clinically and radiologically a fracture of the vault was present. Combined skull fractures were present three times as often in patients brought in dead as in patients dying later, whereas fractures of the vault alone or base alone were more common in patients dying later. Absence of skull fracture was equally common in those brought in dead and in patients dying later.

Seven motorcyclists, including the only pillion-passenger, were dead on arrival, three had basal and three had combined vault and basal fractures. The remaining patient had an atlanto-occipital dislocation but no skull fracture. Four motorcyclists died after arrival at hospital, one had no skull fracture and one each had vault, base, and combined vault and base fractures.

Among six pedestrians who were dead on arrival, three did not have a skull fracture and one each had vault, base and combined fractures. Two of the three patients without skull fracture had dislocations of the upper cervical spine. One quarter of the eight pedestrians who died later had no skull fracture, three had vault fractures and three had basal fractures.

Vehicle occupants accounted for ten deaths, of whom six were brought in dead. One of the latter group had a combined basal and vault fracture, two had vault fractures only, two had basal fractures only and one had no fracture. Three of the four vehicle occupants who died after admission had basal fractures and the other patient had a vault fracture.

Skull fractures however diagnosed, occurred in one hundred and fifty-six (2.3%) of all 6685 head injury attenders. In eighty-nine patients diagnosis was radiological, in twenty-eight both clinical and radiological, in twenty-one clinical (5 of these died and all had fractures at post-mortem), in fifteen BID's at post-mortem and in three other patients at autopsy only.

2. Brain Contusions:

Brain contusions were present in thirty-three patients (70%) and were commoner in patients dying after arrival at hospital (75%) than in those brought in dead (65%). Eight of these cases with contusions, including five brought in dead, had no skull fracture. Contusions occurred in 93% of cases with basal fractures compared with 75% of cases with vault fractures and 63% of cases with combined fractures. Major or complete loss of brain substance had occurred in two patients with vault fractures alone and both these patients were counted as having no cerebral contusions.

Death before reaching hospital occurred in 46% of cases with cerebral contusions and a further third died in the first twenty-four hours. Six patients (18%) survived longer than three days: one seventy-four year old man without a skull fracture died from bronchopneumonia after two weeks; another ninety year old woman, also with no skull fracture, died after four and a half days; one young man died on the eighth day and a middle-aged woman on the sixth day, both had vault fractures and additional injuries; a ten year old male pedestrian with a basal fracture died after eight days and a twenty year old male motorcyclist with combined fractures died on the fifth day.

Eight of the ten vehicle occupants had contusions, one other had cerebral and brain-stem lacerations and the final patient had almost complete loss of brain substance. Four of six pedestrians who were brought in dead had cerebral contusions, the other two had major loss of brain substance and transection of the upper cervical cord respectively. All eight pedestrians who died

later had cerebral contusions. Four of the seven motorcyclists who died prior to admission had cerebral contusions, the remaining three had atlanto-occipital dislocation, gross cerebral lacerations and atlanto-occipital dislocation and severe cerebral laceration respectively. Cerebral contusions were found in three of the four motorcyclists who died later, the other patient having cerebral oedema only. All three cyclists and one third of those injured in falls also had cerebral contusions.

3. Brain Lacerations:

Lacerations of the brain occurred in only eleven patients (23%), one of the eleven also having a laceration of the brain-stem. Six of these patients were dead on arrival at hospital and two of them had major or complete loss of brain substance. A further two patients died during the first twenty-four hours and one each on the second, third and eighth days. All eleven patients had skull fractures - six vault, two base and three combined vault and base. Lacerations were present in three pedestrians (21%), two motorcyclists (18%), five vehicle occupants (50%) and one patient who fell at work (11%).

4. Cerebral Oedema:

Nine patients showed the presence of cerebral oedema at post-mortem, only one of these was dead on arrival at hospital, and four, including this one patient, had no skull fracture. Three had vault and two had basal fractures. Five patients died within twenty-four hours and the others on the third, sixth, eighth and forty-ninth days. Three were pedestrians, two were drivers, two motorcyclists, one a cyclist and one was injured in a fall. Six of them were aged twenty years or less although the oldest patient was eighty-one years old. This patient died from bronchopneumonia seven weeks after admission. She had a subdural haematoma which had been diagnosed but not treated in life.

5. Intracranial Haematomas:

A seventy-three year old woman, who had fallen and died nineteen hours after admission, had a skull fracture clinically and radiologically. No fracture was recorded at post-mortem, however, a massive haemorrhage was present in the right cerebral hemisphere with disruption of the brain. The pathologist recorded this as a natural cause of death due to (non-traumatic) cerebral haemorrhage although the clinical and radiological findings led to her inclusion among the head injury deaths. An additional four patients had post-traumatic intracranial haematomas found at post-mortem. One further patient was known to have a subdural haematoma, she died thirty days after admission and permission for a post-mortem was refused. Of the four patients with haematomas found at post-mortem, one occurred in a ninety year old who was brought in dead and who was taking Warfarin. This patient had both intracerebral and subdural haematomas, but no skull fracture. One of the three cases with haematoma who died after admission had been diagnosed by CT scan as having a chronic subdural haematoma, however, operation was refused and the presence of the haematoma was confirmed at post-mortem. One other patient had a residual collection, having been operated on forty-six minutes after admission when subdural and intracerebral haematomas were evacuated. Finally, a forty-nine year old male front-seat passenger, who died thirty-seven hours after admission never having regained consciousness, was found to have a large extradural haematoma at post-mortem. Two of the four patients had skull fractures and acute lesions. The patient with a chronic subdural haematoma, for whom permission for operation was refused, also had cerebral oedema at post-mortem. The patients with acute lesions had cerebral contusions and lacerations respectively.

The foregoing post-mortem findings and their relationship to time of death and skull fracture are summarised in Tables 4.14-4.17.

Autopsy results defining injuries which occurred outside the skull will now be reported.

TYPE OF PATIENT	SKULL FRACTURE				
	NONE	VAULT	BASE	VAULT & BASE	TOTAL
ALL PATIENTS	16	8	15	8	47
BID	8	3	6	6	23
DIED LATER	8	5	9	2	24
WITH CONTUSIONS	8	6	14	5	33
WITH LACERATIONS	0	6	2	3	11
WITH OEDEMA	4	3	2	0	9

Table 4.14 Gross pathological findings related to skull fracture.

TYPE OF PATIENT	SKULL FRACTURE				
	NONE	VAULT	BASE	VAULT & BASE	TOTAL
BID	5	1	6	3	15
0-6 HOURS		2	2		4
6-24 HOURS	1	1	3	1	6
24-48 HOURS			1		1
48-72 HOURS			1		1
MORE THAN 3 DAYS	2	2	1	1	6
TOTAL	8	6	14	5	33

Table 4.15 Relationship between time to death and the presence and type of skull fracture in patients with brain contusions.

TYPE OF PATIENT	SKULL FRACTURE				
	NONE	VAULT	BASE	VAULT & BASE	TOTAL
BID		3		3	6
0-6 HOURS		1			1
6-24 HOURS		1			1
24-48 HOURS			1		1
48-72 HOURS			1		1
MORE THAN 3 DAYS		1			1
TOTAL	0	6	2	3	11

Table 4.16 Relationship between time to death and the presence and type of skull fracture in patients with brain lacerations.

TYPE OF PATIENT	SKULL FRACTURE				
	NONE	VAULT	BASE	VAULT & BASE	TOTAL
BID	1				1
0-6 HOURS	1	1			2
6-24 HOURS	1		1		2
24-48 HOURS					0
48-72 HOURS			1		1
MORE THAN 3 DAYS	1	2			3
TOTAL	4	3	2	0	9

Table 4.17 Relationship between time to death and the presence and type of skull fracture in patients with cerebral oedema.

6. Spinal Injuries:

None of the patients who died after admission to hospital had fractures or dislocations of the spine, but 43% of those dead on arrival at hospital did have such injuries. Seven cases had cervical and three had thoracic injuries. One patient with an atlanto-occipital dislocation also had a fracture/dislocation of the upper lumbar spine. Of the patients with cervical injuries, three had atlanto-occipital and three had atlanto-axial fracture/dislocations, while the remaining patient had fractures of the bodies of several cervical vertebrae. The overall incidence of cervical injuries among A&E attenders including those brought in dead was therefore 0.3% (23 patients).

Four of the ten patients with spinal injuries were motorcycle riders, three were pedestrians, two were front-seat passengers (1 with and 1 without seat-belts) and one was a cyclist. Only two were female. All the patients with spinal injuries had severe chest and abdominal injuries, six had skull fractures - mostly basal, and in two cases major loss of brain tissue had occurred. All had macroscopic evidence of brain injury.

Two patients dying from trauma, but not having head injury of any significant degree, had spinal injuries. Both died within three hours of admission. One, a sixteen year old girl pillion-passenger, had a fracture/dislocation of the mid-thoracic spine. The other, a sixty-four year old female pedestrian, had a fracture/ dislocation of the sacro-iliac joint. This patient who had severe vascular damage related to her sacro-iliac disruption had a fracture of the nasal bones but no skull fracture or brain injury macroscopically.

7. Chest Injuries:

Nineteen patients brought in dead (83%) and ten who died later (42%) had chest injuries, the overall incidence being 62%. Apart from one patient injured in a fall at work, all the patients

with chest injuries were injured in traffic accidents. Seven of those dying before arriving at hospital were motorcyclists, six were pedestrians, five were vehicle occupants and one was a cyclist. Nine of the patients dead on arrival had pulmonary contusions, all were bilateral, four had unilateral rib fractures, two were associated with fracture-dislocations of the thoracic spine and three had no bony injury in the chest. Amongst this same group of patients, six had pulmonary lacerations, three had bilateral lacerations and bilateral rib fractures, one had bilateral lacerations with unilateral rib fractures, one had unilateral lacerations and fractures and finally, one patient had a unilateral laceration and a fracture of the thoracic spine. Nine patients had bilateral haemothoraces, four with unilateral and three with bilateral rib fractures and two with fractures of the thoracic spine. Heart injuries were present in ten cases, contusions in seven and lacerations in the remainder. Half of the patients with heart injuries had no rib fractures, although one had a thoracic spine fracture. In total, rib fractures occurred in thirteen of the nineteen patients brought in dead, bilateral and multiple in seven, one of these also having a fracture of the thoracic spine. Two of the six patients without rib fractures had fractures of the thoracic spine. Only one patient, who also had bilateral rib fractures and a fractured thoracic spine, had a fracture of the sternum. No patient had a rupture of the aorta although one patient had a ruptured left hemidiaphragm as well as a fractured thoracic spine.

Only ten patients who died after admission had chest injuries. Four were motorcyclists, three were vehicle occupants, one was a cyclist, one a pedestrian and one had fallen at work. All ten were male with ages ranging from ten to forty-nine years, half being 17-20 years. Pulmonary contusions were present in four patients, unilateral with unilateral fractures in two and bilateral without rib fractures in two. No patients had pulmonary lacerations and only three had haemothoraces, bilateral with unilateral rib fractures in one and unilateral but without rib fractures in two. A large pericardial effusion was present in a ten year old boy who died eight days after injury. A male motorcyclist, who died nearly

three hours after admission, had a rupture of his inferior vena cava. Overall six patients had rib fractures, bilateral in only one.

Sixteen patients died following trauma which did not involve significant head injury and six of these were brought in dead. One of the latter, a ninety-six year old man, died following a fall leading to pelvic injury and hypovolaemia. The remaining five cases all had rib injuries, bilateral in two. A fractured sternum as well as rib fractures was present in two of these patients. Pulmonary lacerations were present in two cases, each having lacerated hilar vessels. Unilateral haemothorax was present in two cases and a further two cases had bilateral haemothoraces. Rupture of the aorta and of the left hemidiaphragm occurred in a fifty-eight year old motorcyclist and an aortic laceration with a large haemothorax was present in a thirty-six year old rear-seat passenger. Complete transection of the aorta occurred in a forty-nine year old front-seat passenger. Ten patients without significant head injury died after admission and six had chest injuries including two late deaths (11 days and 20 days) from bronchopneumonia in elderly patients with rib fractures. Three of the remaining four patients had bony injuries in the chest, two had rib fractures and one a fracture/dislocation of the thoracic spine, one also having a fractured sternum. Each of these three patients had pulmonary lacerations and haemothoraces. The fourth patient had bilateral pulmonary contusions, unilateral haemothorax, mediastinal haematoma and avulsion of intercostal arteries, as well as pulmonary lacerations and bilateral intrapulmonary haematomas.

8. Abdominal Injuries:

These were less common than chest injuries, both among those brought in dead and among patients who died later. Ten brought in dead (42%) and nine patients who died later (39%) had abdominal injuries, for an overall incidence of 40%. All those dead on arrival were injured in traffic accidents, four motorcyclists, two pedestrians, two vehicle occupants and one cyclist. One of those dying following admission was injured in a fall and then

partially crushed by a train, the rest were injured in traffic accidents, three motorcyclists, two pedestrians, two vehicle occupants and one cyclist. Eight of the ten brought in dead had ruptured or lacerated spleens, in addition six of these patients had lacerated or ruptured livers. This latter group also included the three patients with torn kidneys. The two patients without splenic injury had renal and hepatic contusions, and retroperitoneal and small bowel contusions respectively. Renal contusions also occurred in two patients with splenic injuries.

One patient who died after admission had a small splenic tear. A further patient had a gross hepatic laceration as well as a ruptured inferior vena cava. Three additional patients had renal contusions, one also having lacerated pelvic vessels associated with a severe pelvic fracture. Three further patients had contusions of the small intestine, intrarenal haemorrhage and posterior peritoneal contusions respectively. Finally the man injured in a fall and then crushed by a train had extensive tearing of the pelvic tissues and major vessels, as well as tearing of the bladder and of the rectum away from the anus.

In those patients dying without significant head injury, one brought in dead had a renal contusion and four of those dying after admission had abdominal injury. Two of the latter had lacerated spleens, one also having a rupture of the right renal artery. Rupture of the left renal artery occurred in another patient with a fracture/dislocation of the left sacro-iliac joint who also had a contused bladder. The fourth patient died six weeks after admission, the cause of death being gangrene of the bowel. This patient had previously been operated on for a rupture of the duodenum associated with a retroperitoneal haematoma.

9. Fractures:

One motorcyclist and one pedestrian, both of whom were dead on arrival, had pelvic fractures, both also had fracture or fracture/dislocation of the cervical spine, as well as chest and

abdominal injuries. Five patients who died after admission had pelvic fractures. Two were vehicle occupants, one was a motorcyclist, one a pedestrian and the other had fallen and then been hit by a train. Two of these five patients had severe hinge fractures with considerable associated visceral and vascular injury. One of the three other patients also had lacerations of major pelvic vessels secondary to the pelvic fracture. In the non-head-injured group of trauma deaths one ninety-six year old man, injured in a fall and dead on arrival, had massive retroperitoneal haemorrhage associated with a pelvic fracture. Two further patients from this group also had pelvic fractures as well as ruptured renal arteries.

Fractures of the upper limbs and/or shoulder girdle occurred in three patients brought in dead, a motorcyclist, a car driver and a cyclist. Fractures in the motorcyclist were bilateral and multiple, and in the other patients were unilateral and involved only one site. All three also had severe head, chest and abdominal injuries. Seven patients who died later had upper limb fractures; pedestrians, motorcyclists and vehicle occupants each accounted for two cases and one was injured in a fall. All except one had unilateral fractures involving one site. In the non-head-injured group of trauma deaths none of those brought in dead, but two of those dying later had upper limb fractures, bilateral and multiple in one patient, a motorcyclist.

Fractures of the lower limb were present in six of those brought in dead, four pedestrians, one motorcyclist and one car driver. These were unilateral and single in three, unilateral and multiple in one and bilateral and single in the remaining two. Two from this group also had fracture/dislocations of the cervical spine, one of these and one other also having pelvic fractures. In addition five patients had chest injuries and three had abdominal injuries of the type already discussed. Six of those patients dying later also had lower limb fractures, three pedestrians, two motorcyclists and a car driver. Five had unilateral fractures involving one site and the other patient had bilateral fractures,

multiple on one side. Four of these six patients also had chest and abdominal injuries, including one motorcyclist who had a ruptured vena cava. In the non-head-injured group no patient brought in dead had lower limb fractures but such injury occurred in five of those who died later. Three of these were late deaths due to bronchopneumonia and the other two died within three hours because of severe chest injuries.

Fractures of the facial bones occurred in five of those brought in dead, two motorcyclists, a cyclist, a car driver and a front-seat passenger. All except the car driver also had spinal fractures or dislocation (2 cervical and 2 thoracic). In addition all had chest injuries and three had abdominal injuries. Upper limb fractures were found in three cases, one also having pelvic and lower limb fractures. Facial fractures were not found in any patient with head injury who died after admission. One patient in the non-head-injured group, who died from severe abdominal injury within fifteen minutes of admission, had a fracture of the nasal bones but no skull or brain injury. No patient from any group had fractures of the hyoid bone or larynx.

10. Combinations of Injury:

The pattern of injury in all sixty-three trauma deaths is shown in Tables 4.18 4.19 4.20. Altogether fifteen motorcyclists died and all had chest injuries, eleven also had head injuries. Seven of those with head and chest injuries had abdominal injuries as well and two with chest injury but no head injury had abdominal injuries.

Twenty-nine patients had fractures, including nine of fifteen pedestrians, seven of fifteen motorcyclists, four of six car drivers, two of four cyclists, two of eight front-seat passengers, one of three rear-seat passengers and four of twelve falls. Three of the four patients who died as the result of falls were late deaths. The most severe combination of injuries (i.e., head, chest, abdominal injuries plus fracture) occurred in nine patients, four

COMBINATIONS OF INJURY	TYPE OF PATIENT	TOTAL
HEAD ONLY	3 FALLS	3
HEAD & CHEST	2 FRONT-SEAT PASSENGERS 1 PEDESTRIAN 1 REAR-SEAT PASSENGER 3 MOTORCYCLISTS	7
HEAD CHEST & ABDOMEN	1 PEDESTRIAN 3 MOTORCYCLISTS 1 FRONT-SEAT PASSENGER 1 DRIVER	6
HEAD CHEST ABDOMEN & FRACTURE	1 MOTORCYCLIST 1 CYLIST 2 PEDESTRIANS	4
HEAD CHEST & FRACTURE	2 PEDESTRIANS	2
HEAD & FRACTURE	1 DRIVER	1

Table 4.18 Relationship between cause of injury and combinations of injury in twenty-three patients brought in dead.

COMBINATIONS OF INJURY	TYPE OF PATIENT	TOTAL
HEAD ONLY	1 FRONT-SEAT PASSENGER 1 CYCLIST 3 FALLS 3 PEDESTRIANS	8
HEAD & CHEST	1 FRONT-SEAT PASSENGER 1 FALL	2
HEAD CHEST & ABDOMEN	1 CYCLIST	1
HEAD CHEST ABDOMEN & FRACTURE	1 FRONT-SEAT PASSENGER 3 MOTORCYCLISTS 1 PEDESTRIAN (NO CHEST) 1 FALL	6
HEAD CHEST & FRACTURE	1 DRIVER 1 MOTORCYCLIST 3 PEDESTRIANS (2 NO CHEST) 1 FALL (NO CHEST)	6
HEAD & ABDOMEN	1 PEDESTRIAN	1

Table 4.19 Relationship between cause of injury and combinations of injury in twenty-four patients dying after arrival at hospital.

COMBINATIONS OF INJURY	TYPE OF PATIENT	TOTAL
CHEST	1 FALL 1 REAR-SEAT PASSENGER 1 DRIVER 1 FRONT-SEAT PASSENGER 1 MOTORCYCLIST	5
FRACTURE	2 FALLS 1 CYCLIST	3
CHEST & ABDOMEN	1 MOTORCYCLIST	1
CHEST ABDOMEN & FRACTURE	1 FRONT-SEAT PASSENGER 1 REAR-SEAT PASSENGER 1 MOTORCYCLIST	3
CHEST & FRACTURE	1 MOTORCYCLIST 2 DRIVERS	3
ABDOMEN & FRACTURE	1 PEDESTRIAN	1

Table 4.20 Relationship between cause of injury and combinations of injury in sixteen patients dying from trauma but not head injury.

motorcyclists, two pedestrians, one cyclist, one front-seat passenger and one patient injured in a fall.

Abdominal injuries were found in twenty-three patients, only one of whom was injured in a fall, although this was the patient who had also been hit by a train. Otherwise, these injuries were most common in motorcyclists (60%) and least common in vehicle occupants (33%).

Head injury alone was present in eleven patients, six of whom had been injured in falls. Pedestrians accounted for three more and cyclists and front-seat passengers one each.

11. Injury Severity Scoring:

The Injury Severity Scores (ISS) for the forty-seven head injury deaths and the other trauma deaths are shown in Figure 4.22. The mean score for these deaths was 34.9, but was 45.4 for those

brought in dead and 24.7 for those dying later. Thirty-eight deaths resulted from traffic accidents and the mean score for these patients was 38.7 (53.8 for BID's and 26.5 for those dying later). The remaining nine patients had a mean Injury Severity Score of 18.7 (12.3 for BID's and 21.8 for those dying later). For non-head injury deaths due to trauma the mean ISS was 31.3 (33.7 for BID's and 29.8 for late deaths). Once more traffic deaths had more severe injuries (mean ISS 37.2) than patients dying from other causes (mean ISS 13.3). Among the head injury patients the highest mean ISS was found in motorcyclists (46.5) followed by vehicle occupants (40.6) and then pedestrians (32.1). For those brought in dead only, motorcyclists again had the highest mean score (50.6), however pedestrians were nearly as high at 50.0, and vehicle occupants (48.2) were only a little below these two. Among patients dying later the mean score for motorcyclists was 39.5, for vehicle occupants 29.3 and for pedestrians 18.8. The mean score for the three cyclists was 37.3. For patients with head injury who were dead on arrival the average contribution to the Injury Severity Score made by the head injury was 21.7 and for patients dying later was 11.7. Thus the average contribution made by other injuries was 23.7 and 13.0 respectively and extracranial injuries were on balance less severe or less numerous in patients who died following admission than in patients brought in dead.

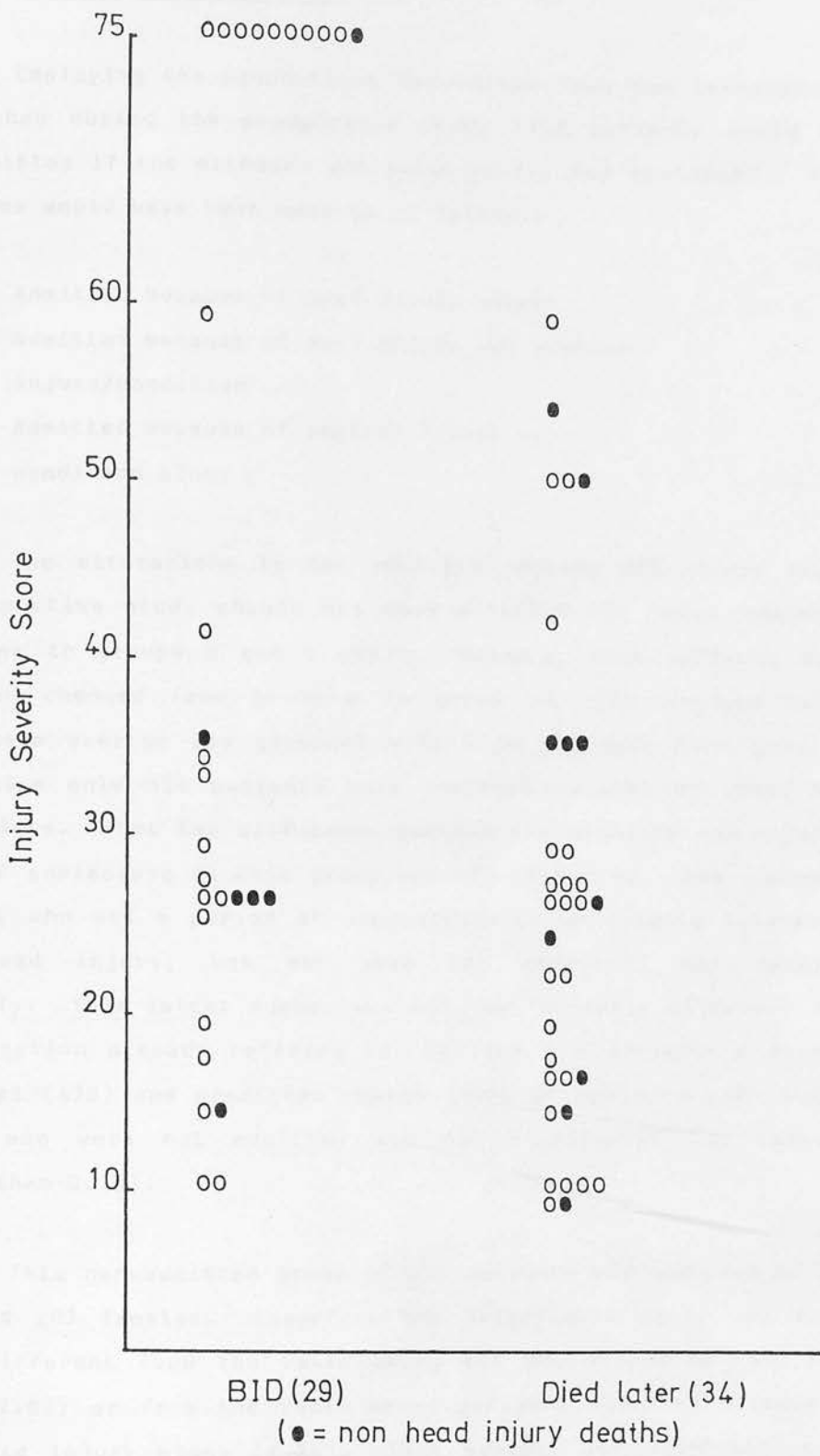


Figure 4.22 Distribution of Injury Scores

4.2.7 Patients Not Admitted:

Employing the proportions determined from the retrospective study, then during the prospective study 1282 patients would have been admitted if the orthodox admission policy had continued. These admissions would have been made up as follows:

a)	Admitted because of head injury alone	- 919
b)	Admitted because of head injury and another injury/condition	- 156
c)	Admitted because of another injury or condition alone	- 207

The alterations to the admission policy introduced during the prospective study should not have affected the total number of admissions in groups b and c above. However, some patients would have been changed from group b to group c. The changed policy should have exerted its greatest effect in patients from group a. In practice only 324 patients were admitted because of their head injury alone. Thus the difference between the observed and expected number of admissions in this group was 595 (919-324). The number of patients, who had a period of unconsciousness or amnesia related to their head injury, but who were not admitted, was recorded separately. This latter number was 630, not markedly different from the estimation already referred to, in fact the difference between the actual (630) and predicted number (595) of patients with such a history who were not admitted was not significant (zI test, p greater than 0.10).

This non-admitted group of 630 patients was composed of 427 males and 203 females. Therefore the male/female ratio was 2.10, little different from the ratio among all A&E attenders with head injury (2.02) or from the ratio among patients admitted because of their head injury alone (2.24). This overall sex distribution in the non-admitted group was not significantly different from that in all attenders (chi-squared = 0.16, p less than 0.7 more than 0.6) or in patients admitted because of head injury alone (chi-squared =

0.12, p less than 0.8, more than 0.7). Among all children, the ratio of boys to girls in the non-admitted group was 1.75 whilst the ratio in patients over sixty-four years was 1.24 but was 2.42 in adults aged 15-64 years. The highest ratio occurred in 20-24 year olds when it was 5.15. The proportions of patients in the non-admitted group aged 0-14, 15-64 and sixty five plus years are shown in Table 4.21, as well as the proportion of all A&E attenders and of patients admitted because of head injury alone. The difference in age-distribution between the non-admitted group and all A&E attenders is statistically highly significant (chi-squared = 50.89, p very much less than 0.0005), as is the difference between the non-admitted group and patients admitted because of their head injury alone (chi-squared = 36.56, p very much less than 0.0005). The age-distribution for those patients who were knocked out or amnesic but who were not admitted is shown in Figure 4.23 and can be compared with the distribution among all attenders (figure 4.6) and among all head injury admissions (figure 4.13). Most of the difference in age-distribution can be explained by the fact that the admission of children, especially 0-9 year olds, was little affected by the change in admission policy, whereas older patients were admitted in fewer numbers but in proportion to their overall distribution.

AGE				
GROUP	0-14	15-64	65+	
NON-ADMITTED	26%	66%	7.5%	
ALL ATTENDERS	41%	52%	7.0%	
HEAD INJURY ONLY	45%	51%	4.0%	

Table 4.21 Age-distribution of patient groups.

Recent consumption of alcohol was noted in 21% of the adults in the non-admitted group and was more common in males (25%) than females (12%). This overall incidence was not significantly

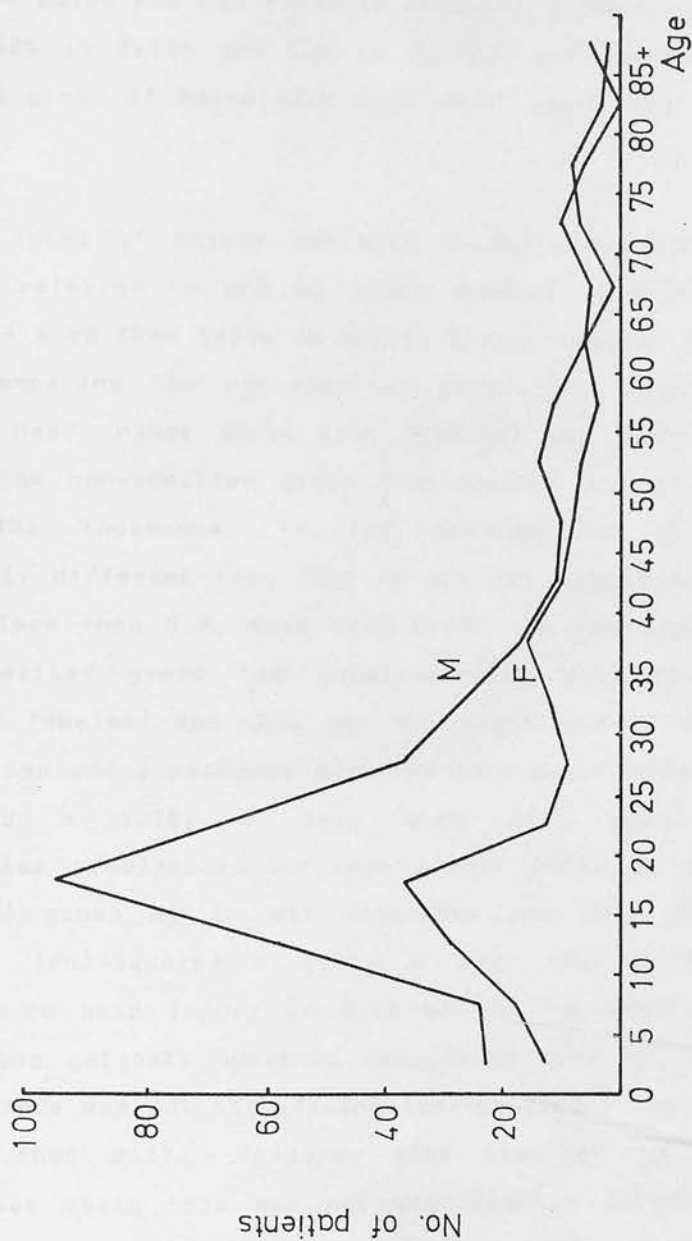


Figure 4.23 Age distribution of non-admitted group

different from that in patients admitted because of head injury alone (chi-squared = 0.26, p less than 0.7, more than 0.6), but was significantly higher than the incidence among all A&E attenders (chi-squared = 39.39, p much less than 0.0005). In the non-admitted group 36% of males who had recently consumed alcohol were injured in assaults, 38% in falls and 19% in traffic accidents. In addition 43% of this group of males were aged 15-24 years and 58% were aged 15-29 years.

A total of thirty patients (4.8%) from the non-admitted group were referred to A&E by their general practitioners. Such referral was more than twice as common among females (7.8%) as males (3.3%). Comparing the non-admitted group with patients admitted because of head injury alone then referral was significantly less common in the non-admitted group (chi-squared = 8.39, p less than 0.005). The incidence in the non-admitted group was not significantly different from that in all A&E attenders (chi-squared = 0.05, p less than 0.9, more than 0.8). In the same way 3.6% of the non-admitted group had cardiovascular predispositions (1.6% males, 7.8% females) and this was not significantly different from the proportion among patients admitted because of head injury alone (chi-squared = 1.78, p less than 0.2, more than 0.1). Cardiovascular predispositions were almost twice as common in the non-admitted group as in all attenders and this difference was significant (chi-squared = 7.37, p less than 0.01). Epilepsy predisposed to head injury in 1.1% of the non-admitted group and 0.3% of those patients admitted because of head injury alone, but this difference was not significant (chi-squared = 0.83, p less than 0.4, more than 0.3). Epilepsy also occurred in 0.8% of all attenders but again this was not significantly different from the incidence in the non-admitted group (chi-squared = 0.38, p less than 0.6, more than 0.5).

Causes of injury in the non-admitted group of patients are shown in Table 4.22 and can be compared with those among all attenders (Table 4.8) and all head injury admissions (Table 4.10). Considering first the commonest cause, falls, then this cause was

AGE	ALL AGES		0-14 YEARS		15-64 YEARS		65 + YEARS	
	n=630		n=166		n=417		n=47	
CAUSE	M%	F%	M%	F%	M%	F%	M%	F%
ASSAULT	16	8.8	2.8	6.7	22	11	7.7	
INDUSTRIAL	7.7	2.5			11	4.1	3.8	
SPORT	5.9	6.4	8.5	8.3	5.4	6.5		
FALL	29	46	45	53	19	34	73	90
FALL BIKE	6.1	2.5	18	5.0	2.4	1.6		
PEDESTRIAN	4.0	2.9	8.5	8.3	2.7	0.8		
CYCLIST	1.9	1.0	4.7	1.7	1.0	0.8		
MOTORCYCLIST	9.8	3.5			14	5.7		
CAR DRIVER	9.6	5.4			13	8.9	7.7	
F. PASSENGER	2.8	6.9	0.9	1.7	3.7	11		
R. PASSENGER	1.2	4.9		1.7	1.7	6.5		4.8
OTHER	5.9	9.9	11	13	3.7	9.0	8.0	5.0
TOTAL [100%]	427	203	106	60	295	122	26	21

Table 4.22 Causes of injury in the non-admitted group.

almost equally common among all attenders (Table 4.8) and among those in the non-admitted group (Table 4.22). However, each of the subclasses of traffic accidents were more common in the non-admitted group than in all attenders. Differences in causation between the non-admitted group and all attenders with head injury were highly significant (chi-squared = 109.32, D.O.F. = 11, p much less than 0.0005) Differences between the non-admitted group and patients admitted because of head injury alone were also highly significant (chi-squared = 35.81, D.O.F = 11, p less than 0.0005).

Differences in the hourly, daily and monthly distributions

between patients who were knocked out but not admitted and other groups were also apparent. Among the non-admitted group peaks in attendance occurred at 12.00-13.00 hours, 16.00-17.00 hours, 21.00-22.00 hours and 00.00-01.00 hours. The latter peak was the highest, although only a little greater than that at 16.00-17.00 hours. The lowest of the peaks occurred at 21.00-22.00 hours. Dividing patient attendances into eight three-hour periods (00.00-03.00, 03.00-06.00 etc) then a highly significant difference was found between the non-admitted group and all attenders (chi-squared = 52.50, D.O.F. = 7, p much less than 0.0005). However, no significant difference was found between the non-admitted group and those patients admitted because of head injury alone (chi-squared = 10.75, D.O.F. = 7, p less than 0.2, more than 0.1).

In the non-admitted group monthly attendances peaked in May and September with the former being higher. In males only peaks occurred during these same two months, but the September peak was higher. In females no September peak occurred, although a peak in May still occurred. The monthly distribution in the non-admitted group was not significantly different from that in all attenders (chi-squared = 17.00, D.O.F. = 11, p less than 0.2, more than 0.1), or that in patients admitted because of head injury alone (chi-squared = 15.74, D.O.F. = 11, p less than 0.2, more than 0.1).

Among the group of patients who were knocked out or amnesic but not admitted the number of daily attendances rose during the week to a peak at the weekend, most attending on Sundays. The daily distribution of this non-admitted group was not significantly different from that of all attenders (chi-squared = 7.94, D.O.F. = 6, p less than 0.3, more than 0.2) or that of patients admitted because of head injury alone (chi-squared = 7.38, D.O.F. = 6, p less than 0.3, more than 0.2).

Vomiting occurred in 7.9% of the non-admitted group and was more common in females (10%) than males (6.8%). Over two thirds of the patients who exhibited this symptom were under twenty-five years old and most of the adult males who vomited had recently consumed

alcohol. The incidence of vomiting in the non-admitted group was not significantly different from that among all attenders (chi-squared = 1.30, p less than 0.3, more than 0.2). However the incidence in those patients admitted because of head injury alone was five times greater than in the non-admitted group and this difference was significant (chi-squared = 146.09, p much less than 0.0005).

At the time of their initial examination 2.2% of the non-admitted group were noted to have neurological signs, nearly always drowsiness and in one case at least this was attributed to alcohol. None of these patients were admitted, presumably because their initial drowsiness disappeared.

Skull X-rays were performed in 39% of all attenders and 72% of patients with a history of unconsciousness or amnesia who were not admitted. This difference was highly significant (chi-squared = 261.14, p very much less than 0.0005). This group of non-admitted patients who underwent skull X-ray examination included three cases with missed skull fractures. The proportion of the non-admitted group who were X-rayed varied with age. In males the range was from 33% in 60-64 year olds to 88% in 5-9 year olds and for all males was 72%. In females this range varied from 43% in 50-54 year olds to 100% in 65-69, 80-84 and 85 plus years. Overall 72% of females had skull X-rays. Only two (0.6%) of the patients admitted because of their head injury alone did not have skull X-rays performed. One had X-rays of the facial bones and the other X-rays of the upper limb. The difference between the non-admitted group and the group admitted because of their head injury only in regard to the proportions undergoing skull X-ray was highly significant (chi-squared = 104.19, p much less than 0.0005).

Tables 4.23 and 4.24 compare various characteristics of the non-admitted group and all attenders and the non-admitted group and patients admitted because of head injury alone.

CHARACTERISTIC	PERCENTAGE OF ALL ATTENDERS n=6685	PERCENTAGE OF NON-ADMITTED n=630	SIGNIFICANCE OF DIFFERENCE
AGE 0-14	41	26	***
AGE 15-64	52	66	***
AGE 65+	7.0	7.5	N.S.
MALE	67	68	N.S.
ALCOHOL [% ADULTS]	11	21	***
GP REFERRAL	5.1	4.8	N.S.
CARDIOVASCULAR	1.9	3.7	*
EPILEPSY	0.8	1.1	N.S.
ASSAULT	12	14	N.S.
INDUSTRIAL	5.7	6.0	N.S.
SPORT	6.6	6.0	N.S.
FALL	33	34	N.S.
FALL BIKE	4.7	4.9	N.S.
RTA	17	28	***
OTHER	14	4.8	***
NOT RECORDED	6.9	2.4	***
VOMITED	6.7	7.9	N.S.
SKULL X-RAY	39	72	***

N.S. = not significant, p more than 0.1

* = p less than 0.01

*** = p less than 0.0005

Table 4.23 Comparison of non-admitted group with all attenders.

CHARACTERISTIC	PERCENTAGE HEAD INJURY ONLY n=324	PERCENTAGE OF NON-ADMITTED n=630	SIGNIFICANCE OF DIFFERENCE
AGE 0-14	45	26	****
AGE 15-64	51	66	****
AGE 65+	4.0	7.5	N.S.
MALE	69	68	N.S.
ALCOHOL [% ADULTS]	23	21	N.S.
GP REFERRAL	9.9	4.8	**
CARDIOVASCULAR	1.9	3.7	N.S.
EPILEPSY	0.3	1.1	N.S.
ASSAULT	7.7	14	*
INDUSTRIAL	3.4	6.0	N.S.
SPORT	6.5	6.0	N.S.
FALL	36	34	N.S.
FALL BIKE	7.4	4.9	N.S.
RTA	26	28	N.S.
OTHER	11	4.8	***
NOT RECORDED	1.9	2.4	N.S.
VOMITED	41	7.9	****
SKULL X-RAY	99	72	****

N.S. = not significant, p more than 0.05

* = p less than 0.01

** = p less than 0.005

*** = p less than 0.001

**** = p less than 0.0005

Table 4.24 Comparison of non-admitted group with patients admitted because of head injury alone.

Follow up of the non-admitted group was for a minimum of three and a maximum of a little over four years. During this time 97 patients (15%) were completely lost to follow up. Neither the age (chi-squared = 8.48, D.O.F. = 4, p more than 0.05 less than 0.10) nor the sex-distribution (chi-squared = 0.27, p greater than 0.6) of this latter group was significantly different to that of the 533 patients successfully followed. Likewise causes of injury were not significantly different between the two groups (chi-squared = 10.18, D.O.F. = 7, p greater than 0.10). A further 8 patients (1.3%) were lost to follow up eight to twenty-eight months after their head injury.

Twenty (3.8%) of those followed died. If the age-specific mortality rates in 1980 (112) continued throughout the follow up period then 11 male and 5 female deaths would have been expected in the 533 patients followed, whereas 16 males and 4 females actually died. This difference between the total number of deaths expected and the observed number is not significant (Poisson's test, p greater than 0.10). The median age at death was 77 years and the range 7 - 100 years whereas the median age at the time of injury was 74 years and the range 5 - 98 years. All save two patients were over 50 years when they died. One 7 year old boy died from a severe head injury sustained eighteen months after the counting injury. A 37 year old man died following an overdose two years after his head injury. Three deaths occurred within twelve months of the counting injury, the earliest occurring at eleven weeks, five died during the second, eleven during the third and one during the fourth year after injury.

Although 505 non-admitted patients were alive 3 - 4 years after their head injury, no information regarding complications was known in 17 (3.4%) of them. In only ten (2.0%) of the remaining 488 non-admitted patients did any complaint possibly attributable to their head injury occur. Six patients had consulted their GP because of headaches, in none did symptoms last longer than 4 months. One patient with headaches also complained of poor ability to concentrate, although such symptoms lasted only 3 weeks. Another

patient complained that he was forgetful/vacant but his GP considered him to be in good health. A 54 year old woman was off work for 4 weeks after her injury and complained of light-headedness for a further 4 weeks, her GP attributed these symptoms to nervous tension. A young man, 22 years old at the time of injury, had episodes of unconsciousness 3.5 and 7 months after his head injury, but no further problems in the ensuing 2.5 years. This patient had suffered convulsions as a child and also sustained two head injuries requiring admission 3 and 5 years prior to the counting head injury, on one occasion fracturing his skull. Finally a baby girl, 9 months old at the time of her head injury, sustained a further head injury with skull fracture 2 months after the counting injury. Immediately after the latter injury she fittted and subsequently suffered "breath-holding" attacks. There was a family history of epilepsy and an EEG was non-specifically abnormal.

Additionally, so far as the hospital is aware, no complaints have been made or litigation arisen regarding any of the 630 patients in the non-admitted group. In view of the time elapsed this must be taken as further confirmation of the efficacy of the more selective admission policy.

4.2.8 Comparison Of The Two Study Groups:

In table 4.25 some characteristics of the total number of head injury attenders during each twelve month period are compared.

CHARACTERISTIC	PERCENTAGE 1976-1977 n=5768	PERCENTAGE 1979-1980 n=6685	SIGNIFICANCE OF DIFFERENCE
n AS % OF NEW A&E PATIENTS	17	18	****
AGE 0-14	45	41	****
AGE 15-64	49	52	***
AGE 65+	6.1	7.0	*
MALE	68	67	N.S.
ALCOHOL [% ADULTS]	9.2	11	*
GP REFERRAL	5.3	5.1	N.S.
CARDIOVASCULAR	1.5	1.9	N.S.
EPILEPSY	0.8	0.8	N.S.
ASSAULT	9.4	12	****
INDUSTRIAL	5.9	5.7	N.S.
SPORT	6.4	6.6	N.S.
FALL	37	33	****
FALL BIKE	4.7	4.7	N.S.
RTA	17	17	N.S.
OTHER	15	14	N.S.
NOT RECORDED	4.3	6.9	****
VOMITED	7.4	6.7	N.S.
KNOCKED OUT	15	15	N.S.
AMNESIC	7.3	6.9	N.S.
SIGNS	4.9	4.8	N.S.
SKULL X-RAY	50	39	****
% OF SXR = # SKULL	3.1	4.5	**
% OF ALL = # SKULL	1.5	1.8	N.S.
HEAD INJURY ONLY	14	4.8	****
HEAD INJURY+OTHER	2.3	1.0	****
OTHER ONLY	3.1	4.9	****
(HI+OTHER)+OTHER ONLY	5.4	5.9	N.S.
INTRACRANIAL HAEMATOMA	0.09	0.16	N.S.
ALL DEATHS	1.1	1.3	N.S.
HEAD INJURY DEATHS	0.7	0.7	N.S.

N.S. = not significant, p more than 0.05

* = p less than 0.05 *** = p less than 0.005

** = p less than 0.01 **** = p less than 0.0005

Table 4.25 Comparison of the two studies.

Dividing the two major study groups of all attenders into unit classes with a unit class-width of five years and counting all patients over eighty-four years as one class confirms the significant difference between the two populations in regard to their age-distribution already noted for the three broad age-groups (chi-squared = 46.16, D.O.F = 17, p less than 0.0005). The most noticeable differences occurred in 0-4 and 5-9 year olds, there being a 4.6% difference in the aggregate proportions for the two age groups, with the higher proportions in the retrospective study.

If, instead of comparing causes via a series of fourfold contingency tables, a direct comparison is made between the eight different groups of causes in each series then a highly significant difference between the two is found (chi-squared = 70.88, D.O.F. = 7, p much less than 0.0005).

As well as the characteristics of each group recorded in Table 4.25 comparison of the hourly, daily and monthly distributions of the two series were made. Dividing each by their time of attendance into eight groups (00.00 - 03.00 hours, 03.00 - 06.00 hours etc.) and comparing them no significant difference was found (chi-squared = 8.44, D.O.F, = 7, p less than 0.3, greater than 0.2). Similarly no significant difference was found when the monthly distributions were compared (chi-squared = 16.60, D.O.F = 11, p less than 0.2, more than 0.1). Whereas, however, the daily distribution did differ significantly (chi-squared = 16.14, D.O.F = 6, p less than 0.025). This latter difference largely occurred because of differing attendance rates on Fridays and Saturdays between the two series (Figure 3.11 and Figure 4.11) and to a lesser extent on Wednesdays and Thursdays.

During the retrospective study 23 head injury attenders (0.4%), who had been discharged, returned to the A&E department because of new or continuing symptoms and following reassessment were again sent home. A further 8 attenders (0.1%) returned and were admitted. Six more patients (0.1%), who had been admitted for observation originally, re-attended and were re-admitted. During

the prospective study the numbers in each of these groups were 61 (0.9%), 20 (0.3%) and 7 (0.1%). Thus about 1 more patient re-attended each week during the prospective study than might have been expected from the retrospective study and about one more patient than expected was admitted from this group each month; re-admissions remained unaltered. During both periods about one quarter of re-attenders were admitted.

Discussion

In 1976 Field (14) reported the complete lack of information regarding patients with head injury who attend A&E Departments in Britain, as well as the paucity of information from the rest of the world. Since that time studies from Scotland (17, 18, 19, 50, 428), Nottingham (51) and Newcastle (52) have been published. The latter covered only a four week period in 1977, gave scant epidemiological information and omitted demographic details. The study from Nottingham concerned itself primarily with admission policy, giving only passing mention to epidemiological data on A&E attenders. The Scottish studies were more comprehensive and defined information relating to more or less the whole of Scotland in 1974 (17, 18, 19), although Swann et al (50) discussed only adult attenders at one AED, whereas more recently Welch (428) reported brief details of attenders of all ages at one department during the years 1976-1979. By sampling A&E Departments during one week in winter and one week in summer, SHIMS identified over 3000 patients (17, 18, 19). The studies reported here discuss more than twelve thousand attenders at one A&E Department during two more recent twelve month periods.

Based on the study by SHIMS the A&E attendance rate for head injury in 1974 was 1778/100,000 (19) with an average of 11% of all new A&E patients suffering a head injury (18). During the retrospective study in Chester the overall attendance rate was 2218/100,000 and attenders with head injury represented 17% of all new A&E patients. Since head injury admissions and therefore presumably A&E attendances have increased steadily in the last twenty years (figure 2.1), part of the difference in rates could be accounted for by the later period of the Chester study, particularly since national statistics for England and Wales show a peak in head

injury admissions in 1976 (figure 2.1). Significant bias of the age-distribution of the Chester catchment population towards younger age-groups compared to the country as a whole (section 3.2.1) would also tend to increase the overall attendance rate, since younger age-groups have the highest age-specific rates (19). A more liberal definition of head injury in the Chester series and/or a truly higher incidence could also help to explain any differences. Facial fractures (N802) accounted for 11% of the total estimated discharges and deaths from head injury in England and Wales in 1976 (table 2.1). This category of patients was not included in the definition of head injury used by SHIMS, but was included in the definition employed for the retrospective study. This difference would necessarily increase attendance rates in Chester compared to Scotland. If the definition utilised for the Chester study allowed the inclusion of more minor injuries, then comparison between Chester and Scotland should reveal major differences. For example, the number of patients with radiologically proven skull fractures might be expected to be lower in Chester than in Scotland. However, during the retrospective study, the proportion of X-rayed patients who definitely had a skull fracture was 3.1% in Chester compared to 2.7% in Scotland (18), whereas the proportion of all patients who had a fracture was 1.5% in both series, assuming those not X-rayed had no fracture. Similarly the overall mortality in Chester was 0.7% in 1976-1977 and in Scotland was 0.1% in 1974, however, it seems probable that SHIMS omitted BIDs from their results, whilst head injury deaths were probably more broadly defined in Chester. A history of altered consciousness and neurological signs on examination were almost identical in their incidence between the two series (18 and section 3.2.3v). Such comparative evidence suggests that the two series are similar. Likewise patients included in the prospective study are similar to those in both the Scottish and the retrospective series, as evidenced by these indices of severity. The higher attendance rate in Chester, therefore, reflects some differences in definition, the later period of the retrospective study, its younger population or possibly a truly higher rate.

As shown in section 3.2.2 the workload of the A&E

Department in Chester is biased towards trauma, with over 60% of admissions from the department resulting from injury. The diluting effects of medical cases and self-referral with minor problems, which are more common in urban departments, are absent. This could explain the higher proportion of new A&E patients which head injuries comprise in Chester (17%) compared to Scotland as a whole (range 6-16%) (18) and to Nottingham, where only 10% of all new adult attenders in 1977 had suffered a head injury (51). Differences in definition would also account for some of this difference.

Notwithstanding the significant bias of the catchment population to younger age-groups, the age-distribution of the retrospective series was the same as that defined by SHIMS (17) and similar to that reported by Maitra (52) and by Welch (428). In 1976 the age-distribution of the Scottish population (75) was slightly more "youthful" than that of England and Wales (68). Thus 24.1% of the Scottish population were aged 0-14 years (75) compared to 22.7% in England and Wales (68); for 15-24 year-olds the proportions were 15.5% in Scotland (75) and 14.3% in England and Wales (68). In Chester during the retrospective study 24.5% of the catchment population were aged 0-14 years and 14.3% were aged 15-24 years, during the prospective study the proportions were 21.8% and 15.7% respectively. If allowance is made for the broader unit class width used by Jennett and MacMillan (19) then age-specific attendance rates in Chester (figure 3.7) were qualitatively very similar to those in Scotland two and a half years earlier. Quantitative differences occurred particularly in younger patients, attenders over 29 years old showed similar rates in both series. Similarly the overall male/female ratio (2.2) in the retrospective series was not markedly different to that (2.4) in Scotland (17) or the ratio (2.0) in Newcastle (52) or Dumfries (2.1) (428). Among all adult attenders in Chester the ratio was 2.2 in 1976-77 compared to 2.8 for the whole of Scotland in 1974 (17), 3.2 among patients over 12 years old attending an inner city AED in 1978 (50) and about 2.3 in Newcastle in 1977 (52). Variations in the ratio with age were generally similar in Chester to those in Scotland (18, 19) and in

England and Wales (14).

Urban/rural differences in alcohol consumption, with city hospitals having higher proportions, were noted by Strang et al (18). In Newcastle 5.4% of attenders had clinical evidence of excessive alcohol consumption prior to their injury (52). In the retrospective study 9.2% of all adult attenders were noted to have recently consumed alcohol compared with 15% of Scottish attenders at hospitals more than thirty miles from a city (18). The proportion in Chester is almost certainly an underestimate and comprises mostly patients who were clearly drunk. Indeed in relation to some causes (assaults), certain age-groups (young men) and times of attendance (23.00-01.00) evidence of recent alcohol consumption was probably the rule rather than the exception and therefore considered not to be worth noting. The common association between drinking, falls and assaults noted by other workers (18, 50, 77, 79, 119) was also apparent in the retrospective series. Likewise recent alcohol consumption was almost twice as common in men (11%) as in women (6%), a finding already well recognised (18, 50, 77).

Causes of injury in the Chester series (table 3.7, figure 3.8) were similar to those in other reported series of A&E attenders (table 2.3). Injuries due to sports accidents and assaults were more common in Scotland (17) than in Chester, although injuries due to traffic accidents were almost equally common in both - 18% in Scotland (17) and 17% in Chester - as were industrial injuries. Lindsay et al (88) suggested that SHIMS used a broad definition of sport and included all leisure activities under this heading. In the Chester series a narrower definition was used, which would explain the lower incidence of sports injuries in the retrospective study. Apparently falls were a commoner cause of injury in Chester (37%) than in Scotland (14%) (18), however, domestic accidents accounted for a further 18% of cases in Scotland (18). Presumably many of these, which comprised mostly elderly people and children, would have been falls. Variations in the cause of injury with age and sex were similar in the retrospective series to those found in other reported series (17, 18, 50, 52). Thus falls were commoner in

children and elderly people, whereas sports injuries, assaults and road accidents were more common in adults, especially young adults. Likewise causes varied little between boys and girls but among adults falls were commoner in women and assaults, sports accidents, works and traffic accidents were more common in men. Moreover among road accident victims, pedestrians were more often children or elderly people and vehicle occupants were usually adults. Subdivision of vehicle occupants according to their position in the vehicle highlighted differences between males and females (figure 3.9). Cyclists and motorcyclists came almost exclusively from well defined age-groups.

Although SHIMS suggested there was no marked difference in the monthly distribution of head injury attendances (17), a significant increase in attendances during the summer months was evident in the retrospective series (figure 3.12). Attendances by children were about twice as high during the summer as during the winter. The proclivity shown by head injuries to occur more often out of office hours and at weekends (17, 18, 48, 50, 52, 131) was confirmed by the retrospective study (figures 3.10, 3.11) and such differences were significant (section 3.2.3 iv).

Initial unconsciousness definitely occurred in 15% of attenders in the retrospective series, a similar proportion to that found in Scotland (18) and on Tyneside (52). Such a history became more common with advancing age, a finding already well recognised (134, 154, 176). Initial loss of consciousness was most common in patients injured in traffic accidents. Almost two thirds of patients with a fracture on X-ray were rendered unconscious initially compared to one fifth of such patients who had amnesia of any duration. Vomiting occurred in one patient out of every fourteen, was most common in children and at all ages was commoner in females. Unlike initial unconsciousness and amnesia, vomiting was most common in patients who had fallen. In Scotland 5% of attenders were not fully conscious when seen in AED (18) and in the retrospective study 4.9% of all attenders had neurological signs, more common in children, in females and in patients injured in road

traffic accidents. Disturbingly, however, in 37% of all head injury attenders either no or an inadequate neurological examination was carried out. Although signs were commoner in females overall (5.7% vs. 4.6%), for patients with a radiologically proven skull fracture this trend was reversed (39% vs. 44%). In the prospective study 34% of all attenders had no or an inadequate neurological examination, whereas 4.8% definitely had neurological signs. Even those patients who had definite fractures on skull X-ray did not invariably have the presence or absence of signs recorded. Thus in the prospective study 2.6% of patients with a proven skull fracture had no or an inadequate neurological examination.

Throughout Scotland in 1974 58% of all A&E attenders underwent skull X-ray examination (18) compared to 65% of adult attenders in inner Glasgow in 1978 (50), 62% of all attenders in Newcastle during the previous year (52) and 62% of all attenders in Dumfries from 1976 - 1979 (428). During the retrospective study half of all head injury attenders had skull X-rays and 3.1% of those X-rayed had a skull fracture or diastasis. Assuming those not X-rayed had no skull fracture, the overall incidence of radiologically proven fractures was 1.5% in Scotland (18), 0.9% on Tyneside (52), 2.5% in Dumfries (428) and 1.5% in Chester. Generally the relationship between the presence of a fracture on skull X-ray and evidence of brain damage was similar in the retrospective series to that in other reports (18, 52). In the adult urban series reported by Swann (50) 13% of all radiologically proven skull fractures were missed by the A&E staff and two thirds of these patients with missed fractures were discharged. In the same series false positive reports were made in two patients, equivalent to 8.3% of those with definite fractures on X-ray. In the retrospective series from Chester false negative reports were made by the A&E doctors in eight patients (9% of definite fractures) and all were sent home. In two further patients (2.2% of definite fractures) the skull films were wrongly thought to show a prominent vascular marking and a fracture of the ipsilateral orbit, both these patients were admitted. Thus 11% of definite fractures on X-ray were missed. In three additional patients (3.4% of definite

fractures) the A&E doctor considered the X-ray appearances suspicious of a fracture, in each instance the patient was admitted and subsequent reporting confirmed the presence of a fracture. False positive reports i.e., skull films reported by the A&E doctor as showing a fracture or ? fracture, but reported by the radiologist as showing no bony injury, were made in thirty-seven patients, equivalent to 42% of all those with definite fractures on X-ray and much higher than reported by Swann (50). There are many possible reasons for misdiagnosing a fracture, not least of these is the relative inexperience of the A&E doctor viewing the films in the majority of cases. Since the presence of a fracture or ? fracture is an absolute indication for admission, making such a diagnosis will, for example, lead to the admission of patients who might otherwise pose a disposal problem e.g., because of their age, social circumstances, alcohol intake or time of arrival. Alternatively a doctor might be 'worried' in a particular case or be playing a hunch and in the absence of any other definite indication for admission suggests that the X-rays show a fracture. In a patient with other indications for admission the doctor may be less critical in his appraisal of the skull X-ray or be guilty of guilting the lily. Likewise in a patient thought to have a fracture clinically the doctor may more readily misdiagnose a fracture on X-ray. Accepting the validity of these possible explanations, then the group of patients with false positive reports is far from homogeneous. In nine of the patients with missed fractures the only reason for admission was the supposed fracture. Seven of these nine patients presented after 17.00 hours, three of the seven presented after midnight, whereas 41% of all admitted patients presented between 09.00 and 17.00 hours. This is compatible with misdiagnosis due to inexperience, since the most junior doctors are most likely to be unsupervised or to have no access to a radiologist during the period 17.00 to 09.00 hours. Recent alcohol consumption was more common in adults with false positive reports (29%) than in all adult admissions (16%). Among all men with false positive reports recent alcohol consumption was noted in 36% compared to 18% in all admitted men and for women the proportions were 11% and 20% respectively.

During the prospective study radiological findings were similar to those during the retrospective study. Thus 1.8% of all attenders, whether X-rayed or not, had a fracture on skull X-ray. Missed fractures, including one patient not X-rayed on his initial visit and one patient with a sphenoid fluid level, occurred in twelve cases (10% of radiologically proven fractures); all but one of these patients was discharged initially. In six further cases (5% of fractures) the A&E doctor considered the films suspicious and in each case the radiologist confirmed the presence of a fracture. False positive reports by the A&E staff numbered forty-seven, equivalent to 40% of definite fractures on X-ray.

In the retrospective study fractures or dislocations of the limbs were present in 4.9% of all attenders, whether X-rayed or not. Similarly only 0.1% of all attenders had cervical injuries detected radiologically and 0.8% had chest injuries identified on X-ray. One in five patients, who experienced an initial period of unconsciousness, had at least one extracranial fracture and this finding was commoner in males (21%) than females (16%). More than twice as many males with neurological signs had extracranial fractures (26%) as did males without signs (10%). Overall nearly one out of every five patients X-rayed had at least one positive radiological finding due to trauma and 2% had more than one positive finding. Again results from the prospective study were very similar to those noted above. Thus 5.5% of all attenders, whether X-rayed or not, had limb fractures or dislocations, 1% had chest injuries and 0.2% had cervical injuries. One in five patients X-rayed had at least one positive finding and 3.3% had more than one positive finding.

The crude admission rate for head injury in England and Wales in 1976 was 313/100,000 (68) and in 1977 was 290/100,000 (69), but in the retrospective study was 357/100,000. This latter rate although higher than the national rate is within the range (210 - 360/100,000) quoted by Jennett and MacMillan (19) for England and Wales in 1974. The rate for Mersey Region during 1975 - 76 was 312/100,000 (56). The higher rate in Chester may be explained in

the same way as the higher overall attendance rate, which the admission rate must reflect, i.e., a significantly younger catchment population compared to the country as a whole, some differences in definition, the later period of the Chester study or a truly higher incidence. A different or more liberally interpreted admission policy is unlikely in the author's opinion to account for the higher rate in Chester. Moreover the discharge rate for head injury in Scotland was 368/100,000 in 1976 (97) and 366/100,00 in 1977 (98), both very similar to the rate in Chester, which in terms of age-distribution is more like Scotland than England and Wales. Furthermore these Scottish rates include patients with facial injuries (N802), as do the rates for Chester and England and Wales, but not the rates quoted by Jennett and MacMillan (19).

Only 16% of head injury attenders at Chester Royal Infirmary were admitted because of their head injury compared to 23% of Scottish attenders and 22% of attenders in Cleveland in 1974 (19) and 46% in Dumfries in 1976 - 1979 (428). However, 19% of all head injury attenders, irrespective of their reason for admission, were admitted in Chester. This might support the contention that in Chester all attenders included relatively more patients with minor injuries, but indices of brain damage, as shown earlier in this discussion, were very similar in Chester to those in other reported series. Moreover in Nottingham in 1977 only 13% of adult attenders with head injury were admitted (51) and in the same year on Tyneside 17% of a small sample of attenders of all ages were admitted (52), whereas 28% of adult attenders in inner Glasgow in 1978 were admitted (50). MacMillan et al (25) found more than one third of attenders at hospitals more than thirty miles from a neurosurgical unit were admitted compared to 19% at city teaching hospitals and 22% at hospitals less than thirty miles from a neurosurgical unit. The AED at Chester Royal Infirmary is approximately twenty-seven miles from the regional neurosurgical unit at Walton Hospital, Liverpool.

Allowing for the narrower unit class-widths in the Chester series, age-specific admission rates in Chester (figure 3.14) were

qualitatively very similar to those in England and Scotland (19). Higher rates in young adults were, however, more emphatic in the Chester results. The sex ratio (2.2) among admitted patients in Chester was little different to that (2.3) in Scotland in 1974 (17) or to that in other recent series (14, 52, 428). Broad age division into children (0-14 years), adults (15-64 years) and elderly patients (65+ years) reveals almost identical proportions in Chester to those in other reports (14, 17, 25). Likewise variations in the sex ratio with age were also similar to those in general series from Scotland (17, 25), adult series (16, 33) and childrens series (60, 61, 62, 63), as well as to those in national statistics from England and Wales (14, 66 - 71, 74) and from Scotland (20, 72, 75, 97, 98).

Recent consumption of alcohol occurred in 38% of adult admissions to Scottish primary surgical wards, but was twice as common in city teaching hospitals (47%) as in hospitals more than thirty miles from a neurosurgical unit (23%) (25). In one Glasgow hospital 52% of adult head injury admissions had recently consumed alcohol (77) and in Northern Ireland 42% of those admitted with mild head injury had been drinking (80). This latter proportion is identical to that found among direct admissions to Edinburgh Royal Infirmary (73). In Chester, however, only 16% of adult admissions were noted to have been drinking, although as in the Scottish series (17) this proportion was significantly higher than the proportion in all A&E attenders. The lower proportion in Chester was probably in part due to its less urban setting and was therefore in keeping with MacMillan's observations (25). However, as suggested earlier, under-reporting was probably a more significant reason for the difference. Notwithstanding, variation in alcohol consumption with age, sex and cause was similar in Chester to that in other reported series (25, 77).

Pre-existing epilepsy was found in 1.3% of head injury admissions in Chester, compared to a prevalence of 0.5% in the U.K. (76), an incidence of 2.1% in Kerr's study (33) and of 2.7% in Maitra's report (52).

Causes of injury among admitted patients in the retrospective series and their variation with age and sex (table 3.9, figure 3.15) were similar to those in other British series (tables 2.4, 2.5, 2.6). Road traffic accidents, which were significantly commoner among admitted patients than in all attenders, accounted for 36% of injuries leading to admission in Chester and 34% of such cases in Scotland two years earlier (17). The proportions due to industrial accidents were also similar between the two series, but sports injuries and assaults were only half as common in Chester as in Scotland. The difference in regard to assaults is in keeping with urban/rural differences noted by MacMillan et al (25). However, these latter authors reported that sports accidents were commoner in rural than in urban areas. This discrepancy, Chester showing a rural incidence of injuries due to assaults, but an urban incidence of sports accidents, is not explained unless due to differences in the definition of sport. Pertinent to this point is the report by Lindsay et al (88). They suggest that SHIMS included all leisure activities under the heading of sport. In Chester a narrower definition was used. Causes of injury in Chester were also similar in their incidence to those in series from Australia (119, 121, 122), Canada (48, 134), Ireland (135, 172), Finland (136), Formosa (137), India (140, 141, 142, 143), Nigeria (144, 145), Norway (146), Sweden (150) and the United States (154, 160, 161, 162, 168). Series from abroad, however, generally showed a higher incidence of traffic accidents e.g., 80% in one series (144). Sometimes selection of patients clearly accounted for the differences (135, 161) and must be presumed to account for the differences in other cases, probably via the operation of a different admissions policy. Local differences in the relative frequencies of different causes would also play their part. Nevertheless variations in cause with age and sex were also similar in series from abroad to those found in Chester.

The hourly, daily and monthly distributions of admissions in the retrospective series (figures 3.17, 3.18, 3.19) generally showed the same patterns as reported in general series from Britain (17, 25, 52), adult series (16) and childrens series (62, 63). An

increase in admissions during the summer months, especially in children, was evident in the retrospective series. Significantly more patients were admitted in September and October and significantly fewer in May. Variations of cause with day, month and hour were in keeping with age and sex differences in temporal relationships. Series originating from abroad show similar variations with hour of day (48, 131, 146), day of the week (48, 131, 145, 146, 162, 168) and season (131, 160, 162, 168).

During the retrospective series 76% of admitted patients had been rendered unconscious at the time of their injury, a proportion almost identical to that found among direct admissions to Edinburgh Royal Infirmary in 1979 (73), as well as in Dumfries at about the same time (428). The proportion knocked out among admissions to Cardiff Royal Infirmary in 1958 was only about half that found in Chester (45). In the Cardiff study, however, follow-up of patients revealed that 78% (86% of the original series) had post-traumatic amnesia of some duration. MacMillan et al (25) recorded a history of initial unconsciousness in 44 - 64% of Scottish head injury admissions in 1974. In Chester initial unconsciousness became more common as age increased, a finding already well recognised (134, 154, 176) and confirmed in childrens series from Britain (60, 61, 62). The presence or absence of amnesia was not recorded in three fifths of admissions in Chester whereas the presence or absence of initial unconsciousness was unrecorded in only 6%. Vomiting was most common in children, being present in 41% compared to 55% in an earlier series from Sheffield (62), 30% in a large Canadian series (134) and 22% in an Indian series (142). Early epilepsy occurred in only 1.2% of admissions. This is almost the same as the incidence (1%) in Scotland in 1974 (25), but much higher than the incidence (0.2%) in another recent Scottish series (428). In each of these instances the incidence is considerably lower than that reported earlier by Jennett (23, 24). The most probable explanation for this discrepancy is that the greater numbers of mild head injuries now admitted have produced a diluting effect.

Approximately one quarter of admitted patients during the retrospective study exhibited neurological signs when examined in the A&E Department, this compares with 49% in Ayrshire in the late 1950's (53), at least 21% in Cardiff in 1958 (45) and at least 25% in Newcastle in the 1940's (42). More recently MacMillan et al (25) reported that 16% of admissions were confused or not talking on admission, 3% would not obey and 3% had anisocoria or unreacting pupils. In Birmingham a little over one third of minor head injury admissions had neurological signs, mostly evident as a depressed conscious level (55). Most recently Welch (428) reported that only 4.6% had a depressed conscious level on admission. The earlier studies referred to above (42, 45) generally were more selected and included secondary referrals, which would increase the proportion with signs. Furthermore the diluting effect of a larger proportion with minor injuries will affect recent studies. In Chester signs were commoner in children, which is in keeping with the findings in paediatric series (60, 62). Likewise signs were more common in patients with additional reasons for admission, which is to be expected. An inadequate or no neurological examination occurred in 8% of head injury admissions, disturbing in view of their reason for admission.

A radiologically apparent skull fracture was present in 8.7% of head injury admissions in Chester, but in 7.3% of all head injury attenders, who were admitted, irrespective of their reason for admission. This compares with an incidence of 7% in the whole of Scotland (17, 25), 5.5% in Dumfries (428), 9% of adult admissions in Glasgow (16), 5% of adult admissions in Nottingham (57) and 11% of partially selected admissions in Edinburgh (73). In England and Wales in 1976 approximately 5.5% of the total estimated number of discharges and deaths due to head injury had skull fractures (N800, N801, N803, N804) (68) and the proportion was about the same in the following year (69). In paediatric series 18% (61) - 26% (62) have skull fractures on x-ray, whereas in Chester the proportion was only 12%. This latter result was, however, similar to that (10%) found among children admitted to primary surgical wards in Scotland (25). In common with other series (25,29,60,134) patients in Chester were

more likely to have a skull fracture if they had evidence of brain damage. Fractures were also commoner in patients injured in traffic accidents, in patients with additional reasons for admission and in summer.

During the retrospective series an initial period of unconsciousness was the commonest single reason for admission and was present in 76%. Other traumatic general surgical conditions sufficient to warrant admission in their own right were present in 4.6%, similarly orthopaedic reasons were present in 7.7% and other injuries in 1.1%, some patients having more than one type of injury requiring admission. The overall incidence of such additional reasons is thus similar to that reported in Scotland (25,428). Likewise both in Chester and in Scotland most of these major extracranial injuries resulted from road traffic accidents. In another Scottish series (16), dealing only with adults, 6% had major extracranial injuries, but only 1% multiple major injuries.

Length of stay in Chester was similar in general and for different sub-groups of patients to that found in Scotland (20,25,72,75,97,98,428) and in England and Wales (66 - 71, 74). Four out of every five patients admitted because of their head injury alone were discharged within forty-eight hours compared to only one in five of patients admitted both because of their head injury and because of another injury or condition. The longest median duration of stay in the retrospective series was 11 - 14 days and occurred in patients with orthopaedic problems and in geriatric patients. Stay was also longer than average in patients injured in traffic accidents, in patients with skull fractures and in patients with neurological signs on admission. Seven hundred and ninety-three patients admitted because of their head injury alone accounted for 27% of occupied bed-days, whereas one hundred and thirty-five patients admitted because of their head injury and another injury or condition accounted for 45% of occupied bed-days and the remaining bed-days were accounted for by patients who were admitted because of other injuries or conditions alone. During the retrospective study head injuries precipitated one quarter of all

emergency general surgical admissions but utilised only 11% of available general surgical bed-days. During the prospective study, however, head injury admissions represented 13% of all emergency general surgical admissions and utilised 5.9% of available general surgical bed-days.

Only 1.5% of head injury admissions were transferred to the regional neurosurgical unit during the retrospective study compared to 1.4% of Scottish admissions in 1974 (25), 1.2% of all head injury admissions in Mersey Region in 1975-76 (56) and 2% of such admissions in Dumfries from 1976-79 (428). Although in fairly close agreement these figures are lower than the 5% suggested by Jennett (19). Predating all the above studies Barr and Ralston (53) reported 2% of admitted patients were transferred, whereas 3% of adult admissions to one Glasgow hospital in 1974 were transferred (16).

Accurate incidence rates for post-traumatic intracranial haematoma are difficult to determine. The relative proportions of the different types of haematoma as found in the Chester retrospective series were about what one would expect from a consideration of section 2.1.13. However, the overall incidence of each type was probably somewhat less than expected. The total incidence in the retrospective series was 23/million population as compared to an estimated 25/million population in England and Wales in 1978 (70). Most recently Mendelow et al (429) suggested an average incidence for all surgically significant haematomas of 36/million population/year in Scotland for the years 1974 - 1980. Jones (430) reports the similar figure of 37/million/year in Mersey Region during the years 1975 and 1976. In the prospective series the overall incidence of post-traumatic haematomas was more than double that during the retrospective series i.e. eleven patients (42/million) with fourteen lesions (53/million) between them compared to five patients (19/million) with six lesions (23/million), counting the patient with chronic bilateral subdural haematomas as having one lesion. The author does not consider that this discrepancy arose because cases were missed from the

retrospective series. Inclusion of two patients, who did not attend AED but who had haematomas, in the prospective series may have been inappropriate, especially as neither gave any history of head injury.

The low incidence of early epilepsy, which nevertheless is almost identical to that reported by MacMillan et al (25), has already been remarked upon. Other neurosurgical events also showed a low incidence, pneumocephalus was present in 0.2% of admitted patients, the same incidence as reported by Briggs (296). Depressed fractures occurred with the same frequency (35/million) as in New Zealand and the United States (394).

In England and Wales in 1976 the mortality from head injury was 3% of the total number of discharges and deaths (68,108) and one year later was 3.1% (69,109). In Chester during the retrospective study the mortality was 4.4%. This higher figure has several possible explanations. Definition of a head injury death in the Chester series was rather broad. Thus any patient with macroscopic evidence of significant head injury was counted a head injury death, even though the patient may have had severe extracranial injuries and died from 'multiple injuries'. A further possible explanation is that injuries in Chester were relatively more severe or included a higher proportion with severe injuries. There is some evidence for this latter belief. Thus traffic accidents, which generally cause more severe injuries, were a commoner cause of head injury among admitted patients in Chester (36%) than in Scotland in 1974 (33%) (25) or in England and Wales in 1976 (25%) (68). Likewise the proportion of BIDs in the retrospective series was 45% compared to 36% in England and Wales in 1972 (14). In Mersey Region as a whole in 1975-76 1.2% of head injury admissions were transferred to the regional neurosurgical unit (56), but from Chester the proportion was higher (1.5%). The more rural setting of Chester could provide a further explanation for the higher mortality, since deaths and serious injuries are more common in road accidents occurring in rural areas than in urban areas (86,87). Other series do not report Injury Severity Scores (ISS). The mean ISS of patients counted as head injury deaths in the retrospective series was 39. Subtracting

the average score contributed by the head injury from this overall mean value indicates that patients who died had either one severe extracranial injury (AIS = 4) or two serious extracranial injuries (AIS = 3). Notwithstanding the above explanations Jones and Jeffreys (431) reported that after standardisation for age and sex there were no significant differences in mortality rates between the sixteen hospitals, including Chester Royal Infirmary, which they studied. However, these authors excluded BIDs and only included head-injured patients who had been admitted purely for observation. Their conclusions, therefore, cannot be applied to an unselected group of deaths.

The hospital case-fatality rate in Chester during 1976 - 1977 was 2.5% (excluding BIDs, but including patients who died in AED) compared to 1% in Scotland in 1974 (25) and 1.5% in Mersey Region in 1975-76 (56). Even including the one hundred and seventy-nine patients admitted for reasons other than their head injury in the denominator only reduces the hospital case-fatality rate to 2.1%. The higher rate in Chester must in part at least be due to the same reasons that were advanced in the preceding paragraph. Again, however, Jones and Jeffreys (431) found no significant relationship between hospital case-fatality rates and measures of severity such as duration of stay and the presence of skull fractures. As previously their method of selecting cases, by excluding patients who died in AED and including only patients admitted for observation, prevents comparison with the Chester results on a like with like basis. If patients who died in the accident unit are excluded from the retrospective series, then the hospital mortality was 2.0%, still higher than that in Mersey Region in 1975 -1976.

Although mortality rates in Chester were higher than in England and Wales they showed the same variation with age and sex as reported by Jennett and MacMillan (19). Causes of injury in those dying, elapsed time to death and macroscopic post mortem findings were similar in Chester to those reported by others (sections 2.1.16 and 2.2). Thus in Chester road traffic accidents accounted for 36%

of head injury admissions but 79% of head injury deaths, a finding in line with other reports (14,21,42,53,62,64,108,109,122,127,134,144,145,160,162,184,185,187). Likewise in Chester as in other series the majority of deaths occurred in the first twenty-four hours, two thirds in the retrospective series. The incidence of skull fractures in patients who died in this series (69%) was similar to that in another large series - 70% (184) - and was not greatly different to the proportion in more selected series - 80% (185), 79% (193). The incidence of brain lacerations and/or contusions was also similar in Chester to that in other series (125,184,185,193). However, the incidence of cerebral oedema was lower in the Chester series than in that from Glasgow (193), although it bore the same relationship to youth and absence of skull fracture. Due to differing methods of selection post-traumatic haematomas were less common in Chester than in the series from Edinburgh (185) and Glasgow (193). In the Edinburgh series 8% of haematomas were first diagnosed at autopsy, in the retrospective series the proportion was 60% and in the prospective series was 11% of those alive on admission and having acute lesions.

In summary, therefore, results from the retrospective study in Chester are generally in agreement, often very close agreement, with those reported by other British workers (sections 2.1.1. - 2.1.16), as well as those reported from abroad (section 2.1.17). Such differences as do occur probably reflect the more rural setting of Chester, real differences in the incidence of head injury and of severe head injury, differing definitions or admission policies, a significantly younger catchment population in Chester or temporal trends.

Considering now the prospective series, the A&E attendance rate was 2547/100,000, an increase of 14.8% or 4.3% per annum over the rate in the retrospective series. In absolute numbers the increase was 15.9% or 4.7% per annum. Head injury attenders represented 18% of all new A&E patients during the study period. Once again the age-distribution of the catchment population was significantly biased towards younger age-groups compared to the

population of England and Wales in 1980. Between the two study periods there was a shift in the age-distribution of the catchment population to a peak at 10-19 years rather than 5-14 years. The overall workload in Chester remained biased towards trauma (cf. tables 3.4 and 4.4) compared to the situation one would expect in a more urban department. Despite the reduction in traumatic admissions resulting from the changes in the admission policy more than half of all admissions from AED still followed trauma.

Various characteristics of the two main study populations are compared in table 4.25. Significantly more attenders had sustained head injuries in 1980 than in 1976-77. At the same time total new A&E attendances, which increased by an average of 1,109 each year between 1970 and 1980 (table 4.1, section 4.2.2), actually fell by 551 between 1979 and 1980, but rose by 238 between the period 1.12.78 - 30.11.79 and 1.12.79 - 30.11.80. Almost at the start of the prospective study there was a strike at British Steel, Shotton, followed by eight thousand redundancies. Employees from this plant accounted for a significant proportion of the workload at the AED in the preceding years; most cases having lacerations, crush injuries, burns or corneal or sub-tarsal foreign bodies. This loss of prospective patients could have accounted for all and must have accounted for some of the shortfall in new attendances. Similar changes in other industrial plants and their knock-on effect on individual and family exposure to risk of injury probably explain the remaining deficit. These changes could, therefore, explain the significant difference between the two studies in regard to the proportion of all new attendances which head injuries constituted. If the increase in new patient attendances during the prospective study had been average, then head injury attenders would have made up 17.8% of all new patients. Nevertheless the difference between the two studies would still just have been significant (chi-squared = 3.94, p more than 0.025, less than 0.05). Omission of head-injured patients from the retrospective study due to failure to identify them might provide a further explanation for the significant difference. In the author's opinion, however, it is unlikely that any head-injured patients were omitted from

the retrospective series. Selection of patients was the same during both periods and all patients were selected by myself only.

Again referring to table 4.25 a significant difference was apparent between the two studies in regard to age. Significantly fewer attenders were children and significantly more were adults in the prospective study group. This finding is in agreement with the national trend for head injury discharges (section 2.1.2). In England and Wales in 1973 26% of patients with fractures of the skull or face (AN 138) and 40% of patients with intracranial injury without skull fracture (AN 143) were aged 0 - 14 years (74). By 1978 these proportions had decreased to 24% and 39% respectively (70). Likewise in Scotland in 1975 33% of head injury discharges were aged 0 - 14 years (75) and by 1979 the proportion had fallen to 30% (20). Corresponding increases in the proportions aged 15 - 64 years and 65+ years were evident in Chester and were similar to the trends in England and Wales (67 - 71, 74) and in Scotland (20,72,75,97,98).

Although no significant difference was apparent in the sex ratio between the two series, the ratio decreased from 2.2 to 2.0. This might have been the result of either a decrease in male attendances, an increase in female attendances or changes in both groups. Between the two study periods the male attendance rate increased by 13.6% whereas the female rate increased by 18.9%. Thus a relative increase in female attendances accounts for the lower sex ratio. Again this change reflects the national trend in England and Wales (68 - 71,74) and in Scotland (20,72,75,97,98) in regard to admitted patients.

Recent alcohol consumption was significantly more common in the prospective study. In the author's opinion noting of alcohol consumption underestimated the true incidence during both study periods. No obvious explanation for the higher proportion during the later study exists, although an associated and significant increase in the number of injuries due to assaults may provide part of the answer. An association between high rates of alcohol

consumption and injuries due to assaults has been noted by many workers (18,50,77,79,119). Other associations and predispositions were not significantly different between the two main series.

In regard to causes of injury, assaults were significantly more common and falls significantly less common during the prospective study. The latter difference may be explained by the significant decrease in attendances by children during the prospective study, since falls are a particularly common cause in such patients. Likewise a shift in the age-distribution to a peak in young adults could account for the increase in the number of injuries due to assaults, which are commoner in those age-groups. Moreover trends over the last 30 - 40 years (tables 2.3, 2.4 and 2.5) reveal a tendency for injuries due to assaults to have become more common. Assaults are a commoner cause of head injury in urban areas (16,25,50), thus this cause is less common in Chester than in reports from more urban areas. Significantly more patients had their cause of injury unrecorded in the prospective study. Why this was so is not clear.

The proportion of all attenders definitely knocked out, definitely amnesic and definitely showing neurological signs on initial examination was not significantly different between the two studies, nor was the proportion who vomited (table 4.25). However, the proportion of all attenders who underwent plain skull x-ray examination was significantly less during the prospective study. Two possible explanations for this difference exist. Firstly, not long after the commencement of the prospective study and as part of the teaching programme within the AED, a radiological meeting was held. As a result of this meeting requests for skull x-ray, x-rays of the nasal bones, distal phalanges of fingers, all toes and oblique rib films declined dramatically. Subsequently an increase in requests for skull x-ray did occur but requests never reached their previous level. Requests for the other sites listed above remained at a much lower level, some, particularly requests for x-ray of the nasal bones, were seldom if ever made again. Comparison of tables 3.8 and 4.9 shows nasal bone x-rays were reduced to less than one-third of

their previous level. The second explanation for the significantly lower proportion undergoing skull x-ray is that industrial action by radiographers occurred about halfway through the prospective study period. This action was particularly effective in curtailing requests for skull x-ray. As a result of significantly fewer skull x-ray requests being made (presumably more selective criteria were applied reflecting the severity of the injury) significantly more patients x-rayed were shown to have skull fractures during the prospective study. However, the proportion of all patients, whether x-rayed or not, who had a radiologically proven fracture was not significantly different between the two studies. Likewise the proportion with correctly diagnosed fractures, as a proportion of all patients with skull fractures, was not markedly different between the two studies, nor was the proportion of missed fractures. That the significant difference in the proportions undergoing skull x-ray between the two main groups arose because of differences in the definition of head injury is thought very unlikely by the author and is not borne out by other comparative evidence. Admitting a patient for head injury observation without first taking a skull x-ray must be almost impossible to achieve. Realisation on the part of the S.H.O. in the A&E Department that initial unconsciousness or amnesia no longer necessitated admission may have dissuaded them from requesting skull x-rays in such cases. This would provide a third explanation for the significantly lower number of skull x-rays during the prospective study.

As a result of alterations in the admission policy significantly fewer patients with head injury alone were admitted during the prospective study. In fact such admissions were reduced to about one third of their expected number. At the same time the total number of patients included in the category (head + other) + (other only) was not significantly different between the two, although some patients who would previously have been classified as (head + other) were converted to (other only). Thus patients no longer warranting admission because of their head injury had not merely been transferred to another admitted group.

The incidence of post-traumatic intracranial haematoma was twice as high in the prospective study, but this difference from the retrospective study was not significant. The small sample sizes involved may explain this failure to show a significant difference. Omission of patients with haematomas from the retrospective study is thought unlikely by the author, nor is overdiagnosis in the prospective study considered likely. Autopsy rates were higher during the retrospective study (88% vs. 80%), whereas the transfer rate to the regional neurosurgical unit was the same during both periods (0.2% of all A&E attenders). CT scanning was available during the prospective but not during the retrospective study. Inclusion of two patients with chronic subdural haematomas, who did not present initially to AED but were transferred from medical wards, in the prospective group may have been inappropriate. Similarly the 90 year-old, who was known to have been taking Warfarin and who died at home, did not attend AED. He was identified as a head injury as a result of reviewing all port mortem reports during the study period. The same checking procedures had been undertaken during the retrospective study but apart from the patient with chronic bilateral subdural haematomas failed to identify any patients similar to the three described above. Moreover this patient with chronic bilateral haematomas had originally presented to AED during the retrospective study period and been admitted because of the head injury he sustained when falling off his bicycle. Neither all deaths nor head injury deaths as defined differed significantly between the two studies.

Comparison of figures and tables detailing other characteristics of the two main study groups and not already mentioned, confirm that the two groups are similar in most respects. At this point we can say that except for differences created by the changes in the admission policy or the results of temporal trends the epidemiological characteristics of the two main study groups are generally similar, both to each other and to those in other published works. Such differences that do occur and which cannot be attributed to the above reasons have been reasonably explained by other factors.

We can now consider the efficacy of the more selective admission policy. The age-distribution of the non-admitted group is significantly different to that of all attenders and that of patients admitted because of head injury alone (tables 4.21, 4.23 and 4.24). The non-admitted group contained significantly fewer children, but significantly more adults, whereas the proportions of elderly patients were not significantly different. Since children are least likely to be rendered unconscious from any given injury (134,154,176, sections 3.2.3v and 4.2.3v), omitting this feature from the list of absolute indications for admission will affect children less than adults or elderly patients. Consequently one would expect more children and less adults in the admitted group; this is exactly what happened in Chester. These differences in age-distribution are further illustrated by comparing figures 4.6, 4.13 and 4.23. Vomiting was twice as common in children as in adults (sections 3.2.3v and 4.2.3v) and as this symptom remained a relative indication for admission this furnishes another explanation for the significantly larger number of children in the newly constituted admitted group.

Other significant differences between all attenders and the non-admitted group and between the latter and patients admitted because of their head injury alone are shown in tables 4.23 and 4.24 respectively. Generally such differences can be reasonably explained. Injuries associated with recent alcohol consumption are often surrounded with uncertainties, not least the patient's own amnesia for events, possibly induced by the alcohol rather than the head injury. Likewise alcohol induced dysarthria or depression of the conscious level is common. Quite properly the examining doctor will err on the side of caution in such cases and admit them. Not unexpectedly, therefore, recent alcohol consumption is more common in the non-admitted group (amnesia) and the admitted group (signs) than among all attenders. Collapses of various kinds precipitated by cardiovascular problems are likely to be associated with brief loss of consciousness. Therefore cardiovascular predispositions would be expected to be more common in the non-admitted group than in all attenders, which is the case here. Road traffic accidents are more

likely to result in loss of consciousness than other causes of injury (sections 3.2.3v and 4.2.3v). This would account for the significantly higher proportion of patients in the non-admitted group injured in this way. Conversely injuries due to 'other causes' were most common in children and were among the least likely to cause initial loss of consciousness. Consequently it is not surprising to find that these causes were significantly more common among all attenders than among the non-admitted group. It is not difficult to believe that patients with relatively more serious injuries are more likely to have their mechanism of injury recorded than are patients with trivial injuries. This could explain the finding that significantly fewer patients in the non-admitted group than in all attenders had their mode of injury unrecorded. By the same token skull x-rays are more likely to be requested in patients with more severe injury, as was the case here.

Comparing now the non-admitted group with patients admitted because of their head injury alone (table 4.24) then significant differences in the age-distribution have already been discussed. GP referral was significantly more common in the admitted group. Once more this is to be expected since GPs refer only a selected group from among those they see and such referrals must be expected to include more patients with relatively more serious injuries. Thus Perkin (47) reported that about one in three patients seen in General Practice were referred to hospital but two-thirds of those referred were admitted. Approximately twice as many patients in the non-admitted group had been assaulted and this difference from the group admitted because of their head injury alone was significant. Assaults show almost the least likelihood of producing neurological signs (4.2.3v) and/or skull fractures (4.2.3vi). This, if not offset by their association with alcohol and the resulting difficulties created, would be sufficient reason for the lower proportion of assaulted patients in the admitted group. Furthermore vomiting, a relative indication for admission, was uncommon in assaulted patients. Injuries due to "other causes" were significantly commoner in those admitted because of their head injury alone. This is entirely in keeping with the frequency of

this group of causes in children relative to other age-groups. Likewise the fivefold difference in the incidence of vomiting is a product of the frequency of this symptom in children. It must be almost impossible to admit any patient with a head injury without that patient having undergone skull x-ray examination. In the prospective series only two admitted patients did not have a skull x-ray, whereas 28% of the non-admitted group did not undergo this investigation.

We have already seen that the overall mortality during the prospective study was not significantly different to that during the retrospective study. This despite a twofold increase in the incidence of post-traumatic intracranial haematomas. By this rather crude measure the altered admission policy was no worse than the orthodox policy. During the retrospective study five acute post-traumatic intracranial haematomas occurred in four patients alive on admission but only two of these lesions were treated during life. In the prospective study nine acute post-traumatic intracranial haematomas occurred in seven patients alive on admission and eight of these were treated during life. Despite the clearly superior results in the latter study the difference does not reach statistical significance (p greater than 0.05, Fisher's Test). Ultimately all four patients with acute lesions in the retrospective study died whereas only three of the seven patients with acute lesions in the prospective study died. Again this difference does not reach statistical significance according to Fisher's test (p greater than 0.05). On this basis therefore although the more selective policy is associated with better results than the orthodox admission policy in terms of diagnosis of and outcome from post-traumatic intracranial haematomas the differences are not significant. The higher ratio of acute extradural to acute intradural lesions in patients alive on admission in the prospective study (ratio 5.4) compared to the retrospective study (ratio 1.4) could account for the difference in mortality. Combined intradural and extradural lesions were present in one-quarter of the patients in the retrospective study, but in only one-seventh in the prospective study. However, in the prospective study two of seven

patients alive on admission had more than one acute lesion, whereas only one of four patients in the retrospective study had more than one acute lesion.

Although no longer closely monitored the more selective policy introduced in Chester in 1979 has continued. In the 4 years since its introduction the staff are not aware of any problems arising which could be attributed to the policy. This rather indirect evidence of the efficacy of the policy is reassuring. More concrete evidence is provided by analysis of the non-admitted group. Thus during a lengthy follow up period there was no undue mortality or morbidity. No patient in the non-admitted group died as a result of their head injury, nor did any develop significant complications. Such complaints as did occur were minor and there is no reason to believe that these would not have arisen if the patients had been admitted for bed and breakfast. Indeed others have found similar complaints in patients with injuries of the same and of lesser degrees of severity as the non-admitted group (419, 421, 422). Moreover there were no practical difficulties experienced by the staff in implementing the changes. Although there was an increase in re-attendances during the prospective study, this increase amounted to only one extra patient per week, hardly an unmanageable number. In most respects therefore, the altered policy was associated with no worse results than was current practice; in fact survival of patients with acute post-traumatic intracranial haematomas was better during the prospective study although not significantly so. Likewise recognition and treatment of acute post-traumatic intracranial haematomas while the patient was alive was more likely during the prospective study. Again however this difference was not significant.

The more selective policy introduced in Chester follows from an appraisal of published work detailing the many characteristics of head-injured patients as set out in chapter 2 of this thesis and particularly in section 2.6. Jennett (410) has pointed out that such a policy is common practice in the United States despite the litigious atmosphere prevalent there. Recently a

working party was set up by the Mersey Regional Medical Committee to examine the management of head injuries. This working party was chaired by Mr. Jeffreys and included the author in its membership. It recommended the adoption of the Chester admission policy throughout the Mersey Region. This recommendation has since been endorsed by the Regional Medical Committee. Gratifyingly a national group of neurosurgeons have recently advocated a similar policy for adult A&E attenders (432) and such a policy has already been applied to adults in Nottingham (51). As yet, however, the application of this policy to all age groups has not been reported. Based on the results from Chester introducing such a policy would reduce all head injury admissions by half. At the same time overall morbidity and mortality would be no worse than currently and the outcome in patients with acute post-traumatic intracranial haematomas might be improved. Nationally such a change, given that even brief hospital stay now costs £85.00 (73), could result in a saving of £11,000,000 annually ($£85.00 \times 630 \times 55$ million divided by 262,500).

A C K N O W L E D G E M E N T S

No study of this length or duration would have been possible without the ready assistance of many people. I would like to acknowledge the initial help and encouragement of Dr. Keith Little, former consultant in Accidents and Emergencies at Chester Royal Infirmary, and the continued support of his successor Mr. John Coals. All the general surgeons at Chester Royal Infirmary were also enthusiastic and supported the study throughout its course. The pathologists to the Chester hospitals, Dr. H. Ingham and Dr. T.D.S. Holliday, kindly allowed me access to all post-mortem reports. In a few instances autopsy reports on patients, who were transferred and died elsewhere, were provided by other pathologists.

Much of the re-filing and postponed filing necessitated by the study, was willingly undertaken by the Accident Unit nursing staff on nights, Sisters A. Marshall and C. Hardy and SEN's J. Richards and A. Youngs, to whom I extend my grateful thanks. The reception and clerical staff in the AED, Angela, Pam, Nancy, Joan and Jeanette, allowed their filing to be disrupted for a whole year. They bore this with great good humour and were at all times very helpful. Notes for the admitted patients were sought out and finally run to earth, often in the most unlikely places, by Miss Shone and her staff in Medical Records. The records of patients transferred to the Regional Neurosurgical Unit at Walton Hospital, Liverpool were also readily provided. Mr. Miles and Mr. Jeffreys, consultant neurosurgeons at the latter hospital were also helpful on occasions. Librarians Mrs. B. King and Miss G. Whitefoot of the Postgraduate Medical Centre at the West Cheshire Hospital provided valuable assistance in obtaining references.

Chester District through the District Management Team allocated funds to permit tabulation of the data using the facilities of the Mersey Regional Computer Centre. Otis Elevator PLC very generously allowed one of their employees, Margaret Smith, to type the thesis into their word processor and so facilitate

editing and ensure the quality of presentation.

My wife Kay and my family bore with great fortitude my continual absences and unavailability during the preparation. Moreover, Kay either typed or transcribed this whole work and most of it more than once, coping equally well with my appalling handwriting and syntax, but just managing to retain her sanity and stave off consulting a divorce lawyer.

Finally, in addition to those mentioned above, I would like to express my sincere thanks to the many doctors, nurses and others, whose co-operation and help made the undertaking of this work possible.

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APPENDIX

Further background and methodology

During the retrospective study medical staff in AED comprised: 1 full-time A&E consultant (Dr. K. Little), 2 full-time A&E registrars and 5 A&E senior house-officers; in addition 5 local General Practitioners each undertook one notional half-day session as a clinical assistant, either a morning or an afternoon.

Chester Royal Infirmary had beds in general surgery (103 adults, 20 children), orthopaedic surgery (40 adult, 14 children), ophthalmology (20), ENT (14), medicine (2), gynaecology (2) and dental (2). None of these beds were set aside for head injuries. The main complement of paediatric, medical, geriatric and gynaecology beds were situated at the Chester City Hospital, approximately 2 miles from AED, whereas obstetric and psychiatric beds were situated at the West Cheshire Hospital, about 1 mile from the AED. A Flying Squad was provided from among the staff in AED to attend seriously ill or injured patients at the scene or in transit. This latter service was used on average about once per week and comprised the A&E consultant and/or A&E registrar together with at least one senior nurse and an ambulance man who acted as the driver. The vehicle used was a specially modified and equipped Ford Granada estate.

Within the AED there was one operating theatre, a comprehensively equipped resuscitation room to accommodate two patients and two additional single rooms, as well as spaces for 6 - 10 "walking wounded". There was an A&E X-ray department contiguous with the A&E department with consultant radiological opinion readily available during office hours. Radiographers were freely available from 09.00 - 24.00 hrs. seven days a week, but otherwise were on call. The intensive care unit (ICU) was also immediately adjacent to AED. There was no short-stay or observation ward in the AED or in the hospital. Admissions from GPs went directly to the appropriate ward and did not pass through AED. Patients with head injury presenting to AED and requiring admission went either to a general

surgical ward, the intensive care unit or directly to the regional neurosurgical unit thirty miles away at Walton Hospital. The decision to admit was made by the A&E doctor who saw the patient. He then informed the duty surgical house-officer and the latter saw and examined the patient on the ward. Thereafter the patient was under the care of the consultant general surgeon on call that day. For more seriously injured patients admission to ICU was arranged by the A&E doctor via the registrar or senior registrar on call for anaesthetics, usually after consultation with the registrar or senior registrar on call for surgery. When a patient clearly needed or was thought to need definitive neurosurgical care then, depending on when this need was first appreciated, either an A&E doctor, usually the registrar, or a general surgeon sought advice from the duty neurosurgical registrar at the regional unit. Transfer to the regional unit was then either from AED, from ICU or from a general ward. When appropriate to the patients condition endotracheal intubation, insertion of a chest drain, peritoneal lavage, etc. was undertaken by the A&E staff; indeed some or all of these measures may already have been undertaken at the scene.

The author took up his post as A&E registrar on 1-6-77 and continued until after completion of the prospective study. Thus elucidation of the admission policy in operation during the retrospective study period was in part based on my own first hand knowledge. Discussions with the A&E consultant, senior A&E nurses and doctors still employed in the hospital, who had worked in AED during the retrospective study period or else worked in other specialties, particularly general surgery, served to confirm that the admission policy in operation during that time was that observed by the author during his initial period of employment and subsequently until the changes introduced on 1.12.79.

During the prospective study Mr. J. Coals was the full-time A&E consultant. Registrar, S.H.O. and GP sessions remained at the same levels as in the retrospective study. Myself and two of the GPs were common to both periods. There was no difference between the two study periods in regard to who decided upon which patients to

admit or what treatment measures were undertaken in AED. The Flying Squad continued to operate in the same way, no short-stay or observation beds existed, patients were admitted to general surgical beds or ICU, and transfers were made either directly from AED, from ICU or from the wards. X-ray facilities were the same, although X-ray usage declined during the prospective study for the reasons given in sections 4.1 and 5.

Immediately prior to the commencement of the prospective study the author provided each doctor directly involved, either in the AED or on the wards, with an explanation of the changes about to be introduced. This was essentially a condensation of section 2.6, but included some local information from the retrospective study. Some groundwork had previously been laid in discussion with the consultant general surgeons in the hospital and with the neurosurgeons at the regional unit, as well as in an address given by the author to the Grey-Turner Travelling Club at its meeting in Chester. In addition I gave comprehensive tutorials to each new intake of SHO's and separately to the senior A&E nursing staff. These dealt in detail with orthodox practice and with the proposed changes. Further informal discussions were held with all grades of medical and nursing staff in AED and related specialities involved in the management of head injuries.

During both study periods it was the practice for all A&E records always to remain in the department. Notes for patients admitted or referred to clinics were photocopied and the copies went to the ward or clinic or GP. The names of all A&E attenders were entered in a register in time order. For the duration of the prospective study the register continued to be filled in as before but all filing of A&E cards was held in abeyance. When on duty I checked the accumulated filing against the register and vice versa. Having established that all cards were there or retrieved them if not, I read each card, irrespective of the patients complaint or injury. Thus continuous and almost immediate audit of the more selective admission policy was possible. Any queries could be answered by direct conversation with the doctor concerned, usually

on the same day and often within hours. This process was repeated on alternate Saturdays when I was weekend off and either during or at the end of periods of annual leave, however records never accumulated for longer than about seven days. Although this process was tedious and disrupted the filing throughout the duration of the study, it did not seem to affect the smooth running of the department. Moreover it allowed daily audit of the implementation of the policy and early resolution of queries, when the information was still fresh in the mind.

During both study periods head injury attenders who were not admitted were given a printed sheet instructing them either to consult their own doctor or return to the AED immediately if they developed any of the following: severe headaches, vomiting, drowsiness, giddiness, blurred vision, loss of consciousness, bleeding or discharge from the ears or nose. In the case of children these instructions were given to the accompanying parent or responsible adult. In the case of adults these instructions were given to an accompanying adult whenever possible or else the patient was told to give the sheet to his parent/spouse/other on his return home.

Summary of conclusions:

1. Head injuries form a significant and important proportion of the workload of any A&E department.
2. They are an important cause of death, particularly among young people.
3. The epidemiological characteristics of head-injured patients are remarkably similar, both qualitatively and quantitatively, in Chester, Britain and the rest of the world.
4. In Britain children now represent a slightly smaller proportion of attenders and falls are correspondingly a less frequent cause.
5. Assaults have increased in frequency as a cause of head injury and an associated rise in the incidence of recent alcohol consumption in adults has occurred.
6. Predictive factors for the development of post-traumatic intracranial haematoma are well established and have been quantified.
7. Secondary insults, particularly hypoxia and hypotension, are not infrequent.
8. The diagnosis of compound depressed fracture is too often missed.
9. Delayed diagnosis and missed diagnosis of haematomas are not uncommon.
10. Current practice does not secure optimum survival, particularly for patients with post-traumatic intracranial haematomas. It probably encourages delay.

11. There is a need to:

- a) Formulate an admission policy based on the known epidemiology and designed to maximise survival by ensuring early diagnosis and treatment.
- b) Lay down guidelines for the selection of patients for skull X-ray.
- c) Safely transfer selected patients to regional units.
- d) Prevent secondary insults such as hypoxia and hypotension.
- e) Improve the knowledge and understanding of (junior) doctors in regard to the epidemiology, pathology and management of head injury.

12. Introducing a more selective admission policy in Chester:

- a) Did not lead to an increase in morbidity or mortality.
- b) Reduced head injury admissions by half.
- c) Was associated with an explicit lack of adverse consequences among those patients sent home who would previously have been admitted.
- d) May have increased the likelihood of diagnosing and treating post-traumatic haematomas whilst the patient was alive.
- e) Was associated with a lower mortality from post-traumatic haematomas than was current practice.
- f) Produced a (paper) saving of £50,000 in Chester in one year.